P. F. SENNEWALD

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APOLLO MISSION C (AS-205/CSM-101) SPACECRAFT REFERENCE TRAJECTORY VOLUME IV - CONSUMABLES ANALYSIS

By Consumables Analysis Section,
Guidance and Performance Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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APOLLO MISSION C (AS-205/CSM-101) SPACECRAFT REFERENCE TRAJECTORY

VOLUME IV - CONSUMABLES ANALYSIS

By Consumables Analysis Section

SUMMARY

The analyses presented in this report indicate that adequate margins exist for all consumables for Mission C (AS-205/CSM-101). The service module reaction control system (SM RCS) required 68.4 percent of its available propellant. The requirement for the service propulsion system (SPS) was 94.5 percent of its available propellant. Of the available oxygen (O_2), 56.8 percent was used for power generation by the electrical power subsystem (EPS) and 19.6 percent was used by the environmental control subsystem (ECS). The EPS requirement for hydrogen (H_2) was 82.3 percent of the available H_2. Both the potable and waste water tanks were full at command module (CM) and service module (SM) separation.

INTRODUCTION

Detailed consumables analyses were performed on the CSM-101 RCS, SPS, EPS and ECS for Mission C. The variation in the spacecraft's center of gravity was also investigated.

The analyses were based on the activities in the reference flight plan (ref. 1), the reference trajectory (ref. 2), and other references given in this report. The data used in the analyses were assumed to be accurate to within ±10 percent. The consumables estimates provided by this study were based on preliminary knowledge of crew procedures. The operational procedures described in this study are not intended to define mission rules or crew procedures, but are merely an attempt to establish an estimate of the consumables requirements.

The analyses were performed by the Consumables Analysis Section (CAS) of the Mission Planning and Analysis Division (MPAD). The individuals responsible for the various systems are listed below.

Don A. Nelson. . . . . Propulsion Subsystem

Harry E. Kolkhorst and
Richard C. Wadle . . . . Electrical Power Subsystem

Richard M. Swalin. . . . . Environmental Control Subsystem

Sam A. Kamen . . . . Mass Properties

SYMBOLS

COAS	crew optical alignment sight
CSM	command and service modules
DTO	detailed test objectives
FDAI	flight director attitude indicator
GOX	gaseous oxygen
I_{FC}	fuel cell current
IMU	inertial measurement unit
LIOH	lithium hydroxide
LOS	line of sight
MI	minimum impulse
NCC2	corrective combination
PGNCS	primary guidance and navigation control subsystem
PVT	pressure, volume, temperature
RCAH	rate command attitude hold
RR	rendezvous radar
SCS	stabliization and control subsystem
SCT	scanning telescope
SEP	separation
SXT	sextant

TPI	terminal phase initiation
WSMR	White Sands Missile Range

PROPULSION SUBSYSTEMS ANALYSES AND RESULTS

CM RCS

The following shows the amounts of propellant available and used by the CM RCS for Mission C.

Loaded, lb.	267.6
Residual, lb.	21.6
Available, lb	246.0

Used:

Separation to 0.05g, lb	12
0.05g to drogue chute deployment, lb.	27
Remaining at mission end, lb.	217

The amount of propellant used was taken from reference 3.

SM RCS

<u>Propellant available and associated redline</u>.- The event timeline used for the SM RCS budget is shown in table I. For spacecraft weight analysis, the maximum weight of loaded propellant is 1358 lb. However, for mission planning the minimum expected deliverable (maximum usable) propellant of 1284 lb must be used. This allows for a maximum propellant dispersion due to temperature dispersions of 28 lb and for unexpelled propellants of 46 lb. Reference 4 indicates that the 3σ PVT gauging error is 5.73 percent at an empty condition. For budgeting purposes this error was rounded off to 6 percent and resulted in a 78-lb allowance for gauging. The PVT dispersion error results leave 1206 lb for mission planning (table II). The propellant required for SM RCS deorbit is added to the total unusable propellant to define the redline. The propellant required for an emergency deorbit is a function of the type of deorbit planned. Estimates have been made for four-jet SCS and hybrid deorbits and are shown in figure 1.

<u>Spacecraft maneuver rates and attitude holds</u>.- Attitude maneuvers were calculated as three-axis maneuvers at 0.2 deg/sec. This maneuver rate represents the value chosen for the lunar mission configuration control

budget (ref. 11). The expected pitch moment of inertia is from 60 000 to 43 000 slug-ft^2; propellant consumption for this range has been estimated to 0.7 lb for a three-axis maneuver at 0.2 deg/sec. Should the rate be increased to 0.5 deg/sec the propellant consumption will increase to approximately 1.0 to 1.4 lb for a three-axis maneuver. This would result in a propellant increase of 60.7 lb for the mission.

Allowances of 2.8 lb/hr for narrow deadband and 1.4 lb/hr for wide deadband attitude holds were made for both PGNCS and SCS control modes. These estimates are based on data that include the effects of dynamic disturbances (ref. 5). The MIT PGNCS data do not include this effect and indicate a very conservative 0.1 to 0.01 lb/hr for deadbands of 0.5° and 5.0°, respectively.

Propellant profile.- The SM RCS propellant profile was constructed by evaluating the detailed test objectives (ref. 6) in respect to the reference flight plan (ref. 1). The amounts of propellant required for the detailed test objectives are shown in table III. Figure 1 presents the results of this evaluation as a function of mission time. A substantial margin is available above the active rendezvous where a margin of 75 lb is indicated before the third SPS burn lowers perigee. Analyses of the mission objectives were performed as indicated in the following discussion.

1. P1.6 - IMU inflight alignments.- Approximately 27 IMU inflight alignments have been estimated using programs P51 and P52. This includes those alignments using only P52. A three-axis attitude maneuver at 0.2 deg/sec is assumed for star acquisition for each program. Minimum impulses (MI) of approximately 0.006 lb per pulse are used for minor attitude corrections.

2. P1.7 - IMU orientation determination.- The IMU orientation experiment is to be conducted to determine if star patterns are visible in daylight. The test will be conducted with an aligned IMU. Three-axis orientations and 40 minutes of attitude hold in wide deadband at sunrise and sunset are assumed. This test is planned for four different orbits with one late in the mission to determine optical degradation.

3. P1.8 - Orbital navigation/landmark tracking.- Propellant allowances are made for IMU alignments, orientation to observation attitude, and MI attitude and orbital rate maneuvers. These tests are conducted in two series of three orbits each. The second series is accomplished with one IMU alignment at the beginning of the test instead of one each orbit.

4. P1.9 - SCS attitude reference alignment.- A set of Euler angles will be selected for a manual three-axis orientation to a referenced star. The IMU will have been previously aligned. One additional one-axis maneuver is allotted so that a star pattern can be selected to allow the FDAI display to be 0°, 0°, 0° when the spacecraft is maneuvered back to the burn attitude.

5. P1.10 - Sextant tracking.- In addition to the sextant tracking used during CSM-active rendezvous, a propellant allowance has been made for S-IVB observations at 80, 160, and 320 n. mi. for postrendezvous tracking. Maneuvers involve one three-axis orientation with MI attitude corrections for each of the three observations.

6. P1.13 - PGNCS ΔV capability.- The SM RCS must support the SPS burn by providing that ullage be made for propellant settling and also by providing roll control during the burn. The ullage schedule used in this study is five, 15-second, four-jet ullages and two, 20-second, two-jet ullages. It is important that the crew be aware of the ΔV to be imparted by this ullage to insure proper SPS propellant settling. An SM RCS phasing burn of 7.25 seconds is also scheduled for the PGNCS ΔV tests.

7. P1.15 - Midcourse navigation.- A star-lunar landmark three-axis orientation is required, with each astronaut making a sextant angular measurement using MI control. In addition, a lunar horizon-star observation will be made by one astronaut. At least nine marks are required per observation.

8. P2.5 - SCS ΔV control.- An SCS ullage will be required to support this test. The four-jet translation will be made using the hand controller and will be of 15 seconds duration. It is important that the crew be aware of the ΔV to be imparted by this ullage to insure proper SPS propellant settling.

9. P3.14 - SPS performance evaluation.- Besides the nominal ullage requirement, a propellant allowance for 3σ SPS pointing errors has been made for SPS burns 1, 2, 3, and 7.

10. P6.8 - Overpass simulation/RR.- A three-axis spacecraft maneuver is made so that the RR transponder antenna beam pattern illuminates WSMR. This test is performed twice.

11. M7.19 - Radiator heat rejection and degradation.- A three-axis orientation is made to place one radiator panel toward the earth. The spacecraft is then placed in wide deadband attitude hold for three orbits.

12. M7.21 - SLA deployment system.- The SLA deployment test calls for making two photographs approximately 180° apart and normal to the S-IVB X-axis. Propellant allowance has been made for X, Y, and Z translation for CSM fly-around. These translations may satisfy SCS DTO requirements.

13. P6.22 - SPS propellant thermal control.- A three-axis orientation is made to place the spacecraft in a cold soak attitude (+X-axis toward the sun). The spacecraft is then placed in SCS wide deadband attitude hold for 1 hour.

14. P7.23 - CM RCS thermal control.- This test is to be conducted with the same procedures as DTO P7.22.

15. P20.8 - Separation/transposition/simulated docking.- The maneuver procedures used to define the propellant requirement are the same as those defined for the lunar landing configuration control budget. An additional 10 lb was allotted for index procedure variations.

16. P20.9 - Manual retro-attitude orientation.- A three-axis manual maneuver is planned to orient the spacecraft to the retro-attitude, the spacecraft is then placed in attitude hold. This procedure is made for both night and day side passes.

17. P20.13 - CSM-active rendezvous (TPI to SEP).- Propellant allowances for the CSM-active rendezvous are based on data from the CM procedures simulator (ref. 7).

18. S20.16 - Environmental induced window deposits.- The spacecraft is to be maneuvered 180° in two orthogonal axes to observe the light scattering on the window.

19. S20.17 - Propellant slosh damping.- A propellant allowance of 32.0 lb is made for damping spacecraft rates immediately after SPS cutoff for four of the eight SPS burns. Since it is impossible for the astronaut to evaluate when 8.0 lb of propellant is consumed, this test must be terminated by the frequency of the sound of the jets firing. A nominal allowance of 1.1 lb has been allotted for transient damping for the remaining SPS burns. This allowance is based on waiting 10 minutes before damping spacecraft rates.

20. S20.20 - COAS evaluation.- One three-axis maneuver is made for calibration after each SPS burn except deorbit. It is assumed that the COAS will be stored prior to each burn.

Service Propulsion System

Flight propellant reserve.- For Mission C, the nominal weight of the spacecraft at injection is 36 300 lb. Variations in the hardware weight will be compensated for by adjusting the SPS propellant loading. Thus, the exact SPS propellant loading will not be known until shortly before launch. This report gives the propellant margin for the mission, based on a loading of 9081 lb.

There has been some flexibility in the use of such terms as "usable propellant," etc. For the purpose of this study, the notation established in reference 8 will be used and the propellant available for maneuvers will be calculated based on a total nominal loading of 9081 lb.

Table IV presents the nominal loading condition with the expected dispersions and nominal usage. These results indicate a nominal flight propellant reserve of 451 lb.

The SPS propellant usage was calculated from the following nominal burn schedule (steady state burn times). A 42.8-lb allowance was made for thrust build-up and tail-off for each burn.

Burn	Δt, sec
1	8.15
2	7.05
3	minimum impulse[a]
4	14.375
5	56.179
6	minimum impulse
7	19.328
8	12.32

ELECTRICAL POWER SUBSYSTEM ANALYSIS AND RESULTS

This analysis is based on the electrical power requirements given in reference 5. The timeline used is that of references 1 and 9. The assumptions, conditions, and constraints used for this analysis are as follows:

1. Energy available from entry and postlanding batteries is 120 ampere-hours. These batteries were assumed fully charged prior to the SPS deorbit maneuver. The three batteries were assumed to supply the total spacecraft power requirement for entry, parachute descent, stabilization period at impact, and postlanding.

2. EPS hydrogen consumption rate = $0.00257 \times I_{FC}$ (lb/hr) (as per reference 9).

3. EPS oxygen consumption rate = $7.936 \times$ hydrogen consumption rate (lb/hr).

4. Cryogenic quantities loaded were as follows:

H_2, lb.	56.0
O_2, lb.	640.0

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[a]For the operational trajectory, SPS burn 4 will be the mimimum impulse burn.

5. The system was assumed to operate with two inverters.

6. Eighteen fuel cell purges were assumed as in reference 1.

7. Component power requirements were taken from reference 5.

8. Selective equipment were turned on and off as per reference 1.

9. Prelaunch: Fuel cell requirements from T - 10 to T - 3 hours were 18 amperes. Fuel cell requirements from T - 3 hours to lift-off were 100 amperes.

10. There was no H_2 or O_2 venting.

The electrical power subsystem analysis indicates a requirement of 45.6 lb of H_2 for the nominal mission, as defined in reference 1. The fuel cell oxygen requirement is 356.1 lb. The hydrogen remaining as a function of time is shown in figure 2. The oxygen remaining as a function of time (for EPS and ECS requirements) is shown in figure 3. In addition, for a maximum launch hold of 5 hours, 1.3 lb of H_2 and 10.2 lb of O_2 are required, increasing the total H_2 requirement to 46.9 lb and the total O_2 requirement to 512.4 lb.

The batteries supplied approximately 50 amperes during each SPS burn. The total battery current is shown in figure 4.

The fuel cell currents for fuel cells 1, 2, and 3 are presented in figures 5, 6, and 7. The total fuel cell current versus time is shown in figure 8. The common level current is approximately 62 amperes.

Fuel cell temperature as a function of time is shown in figures 9, 10, and 11. The CM bus A and bus B voltages are presented in figures 12 and 13, respectively.

The total power profile is shown in figure 14; burns may be easily identified by the peak powers of greater than 4000 watts.

The cryogenic requirements for electrical power generation, fuel cell purges, and environmental control subsystem (prelaunch and flight) were as follows:

	O_2, lb	H_2, lb
Loaded	640.0	56.0
Residual	13.0	0.6
Available for mission	627.0	55.4
Fuel cell requirements (power and purge)	356.1	45.6
ECS requirements	148.1	
Available at end of mission	122.8	9.8

The battery energy required for entry and postlanding was as follows:

Battery energy available, kw-hr	3.480
Energy used from separation to drogue chute deployment, kw-hr	0.630
Parachute descent, kw-hr	0.130
Two uprightings, kw-hr	0.224
48 hours postlanding, kw-hr	1.776
Total required, kw-hr	2.760
Remaining, kw-hr	0.720

ENVIRONMENTAL CONTROL SUBSYSTEM ANALYSIS AND RESULTS

This analysis is based on the following considerations:

1. Metabolic O_2 rate for three men was 0.23 lb/hr.

2. Waste management O_2 rate was 1.23 lb/day for three men.

3. Cabin O_2 leakage rate was 0.2 lb/hr.

4. The average metabolic heat produced by the LIOH-CO_2 reaction was 330 Btu/hr.

5. The average heat transfer through the cabin wall was -175 Btu/hr.

6. The metabolic heat load for the crew was 1420 Btu/hr.

7. Average orbital altitude was 150 n. mi.

8. A nominal radiator absorptivity, $\alpha = 0.2$.

9. One CSM pressurization.

10. Fuel cell water production = $0.0235 \times I_{FC} \times$ time.

11. O_2 purge rate of the water tanks was 0.056 lb/hr.

12. Water generated during prelaunch procedures was transferred to the potable tank, creating the following tank quantities at lift-off:

Potable, lb	36
Waste, lb	10

13. The assumptions used to compute absorbed incident heat were as follows:

(a) Circular orbit.

(b) X-axis on the velocity vector.

(c) One radiator perpendicular to the sun at the subsolar position.

The environmental control subsystem analysis produced an O_2 requirement of 148.1 lb. The water produced by the fuel cells was 400 lb. The LIOH-CO_2 reaction produced an additional 29 lb of water; thus, the total water production was 429 lb. The urine dump resulted in a water loss of 86 lb. For a radiator absorptivity of 0.2, the total water evaporated was 48 lb. Due to the assumptions of this analysis, the water boiled should be somewhat higher than that actually encountered during the mission.

MASS PROPERTIES ANALYSIS AND RESULTS

The center of gravity and moments of inertial are calculated on the basis of SPS propellant considered as measurable from the bottom of each tank. Based on the 3σ SPS loading uncertainty and the 3σ uncertainty in CSM inert weights (ref. 10) the x, y, and z center-of-gravity curves shown in figure 15 are accurate to ±0.6, ±0.3, and ±0.3 inches, respectively. It should also be noted that the moment of inertia curves found in figure 16 are accurate to 10 percent (3σ). Table V presents the initial vehicle mass properties at launch and CM mass properties at entry interface. Table VI consists of consumables loadings. The following assumptions were made in generating this study:

1. Mass properties were computed as a function of the depletion of SPS propellant.

2. The third and sixth SPS burns (MI burns) were considered negligible.

CONCLUSIONS

Satisfactory consumables margins are found to exist in all subsystems for the nominal mission.

TABLE I.- SM RCS EVENT TIMELINE

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
	Prelaunch check-out	Pulse each jet 0.75			4.4	
2:55	Transposition & Simulated Docking	+X 4 jet translation 5 sec $\Delta V \approx 1.8$ fps	Current Wt $\approx$ 32,529 $I_{xx} \approx$ 16,460 $I_{yy} \approx$ 58,200 $I_{zz} \approx$ 61,040	SCS	7.3	P20.8
		Null $\frac{1}{2}\Delta V$	Assume IMU Align from S-IVB	SCS	3.7	
		Pitch 180° @ 5°/sec		SCS ~ RCAH	9.0	P 2.4
		Return to S-IVB & Null			3.7	
		Roll 60° @ 2°/sec		SCS ~ Acc Com	1.0	P 2.4
		Indexing	Allowance for various index procedures		10.0	
	SLA photography during S-IVB Fly-around and Station Keeping	Hold narrow Db 10 min. S-IVB X axis	Photograph SLA during docking sim. & fly	SCS ~ 0.2 db	0.5	M 7.21
		Translate ±Z	around ΔVel $\approx$ ±0.5 fps att. hold wide db for photographs Translation & att. maneuvers programmed to satisfy DTO-P2.4	SCS	4.5	P 2.4
		Pitch 90° @ 2°/sec & att. hold	Use MI for observation & photographs	SCS ~ RCAH	3.0	
		Translate ±Y	ΔVel $\approx$ ±0.5 fps		4.5	P 2.4
		Translate ±X	ΔVel $\approx$ ±0.5 fps		4.1	
		Yaw 90° @ 2°/sec & att. hold		SCS ~ RCAH	3.0	P 2.4
		Translate ±X	ΔVel $\approx$ ±0.5 fps		4.1	
		Roll & Pitch @ 2°/sec & att. hold		SCS ~ RCAH	1.0	P 2.4
		Translate ±X	ΔVel $\approx$ ±0.5 fps		4.1	

TABLE I.- SM RCS EVENT TIMELINE - Continued

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
	Increase Distance From S-IVB	Translate X	ΔVel $\approx$ 0.5 fps		2.0	
			SUBTOTAL		(69.9)	
3:33	Orient for RCS Phasing burn	3-axis @ 0.2°/sec/min att. hold 0.5° db	Assume IMU align from S-IVB	PGNCS	1.2	P 1.12
	RCS phasing burn	7.25 fps		PGNCS	26.8	P 1.13
	Orient to monitor S-IVB	3-axis @ 0.2°/sec		PGNCS ~ FREE	0.8	
5:00	Align IMU	3-axis	Landing PT 6-4 check (P-52)		0.7	
		Align IMU	P51, 52		1.4	
7:20	Manual Retro-Att.	Orient 3-axis @ Apogee & Perigee & Att. Hold	Day side pass & Night side pass	SCS~Acc Com	4.4	P20.9
8:00	IMU Align	3-axis	P-52		0.7	
9:00	Power down	2-3-axis/10 min 4.2° db hold to damp drift rate when required	Rates >1°/sec can be used to satisfy SCS att. hold test	SCS ~ 4.2° db	2.4	P 2.4
			SUBTOTAL		(108.3)	
22:55	Power up, Align IMU	2-3-axis	P51, P52		1.4	
24:55	Rendezvous Navigation	3-axis, mark 30 times/MI	P20	PGNCS	0.9	
26:24	1 SPS burn (Δt = 7.9 sec)	Align IMU 3-axis @ 0.2°/sec Orient for SPS burn 3 axis/10 min 0.5 db Ullage 4 jets, 15 sec ΔV $\approx$ 6 fps	P52	PGNCS PGNCS ~ AUTO	0.7 1.2 22.0	

TABLE I.- SM RCS EVENT TIMELINE - Continued

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
		S/C wt ≈ 31,900 lbs	P30	PGNCS		P 1.13
		Orient ~ 3 axis @ .2°/sec			0.7	
			Damp Shutdown transient		1.1	
	RCS Trim	ΔVel ≈ 8 fps		PGNCS	29.6	
	COAS Calibration	1-3 axis			0.7	P20.20
	Observe S-IVB	3-axis, Mark 25 Timeline	P-20, Rendezvous Navigation	PGNCS	0.9	P 1.10
		Align IMU, 3 axis/0.5° db att. hold	P52	PGNCS	1.0	
		Orient ~ 3 axis			0.7	
27:18	RCS, NCC2	ΔVel ≈ 10 fps	May not be necessary	PGNCS	36.0	
	Observe S-IVB	3-axis, mark 5 times/ MI			0.8	P 1.10
		Align IMU - 3 axis @ 0.2°/sec	P52	PGNCS	0.7	
28:01	2nd SPS Burn (Δt=6.5 sec)	Orient, 3 axis @ 0.2°/sec			0.7	
		Ullage 4 jets, 15 sec ΔVel ≈ 6 fps			22.0	
			Damp shutdown transient		1.1	
	RCS trim	Orient ~ 3 axis @ 0.2°/sec			0.7	
		ΔVel ≈ 8 fps		PGNCS	29.6	

TABLE I.- SM RCS EVENT TIMELINE - Continued

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
	COAS Calibration	1-3 axis			0.7	P20.20
			SUBTOTAL		(261.5)	
29:04	Rendezvous	Maneuver to tracking attitude ~~tracking~~	Rendezvous Prop. req'd is the results of FCSD Sims. (CMPS)		1.4 0.2	P20.13
		Back-up Data Collection			7.4	
		TPI Maneuver	44 sec RCS Burn $\Delta V \approx 16$ fps		75.2	
		Maneuver to tracking attitude			1.2	P 1.10
		Navigation Tracking			0.2	
		Back-up Data Collection			3.6	
		Mid-course burn			36.1	
		Braking & LOS Control			131.9	
		Orient 3 axis	Orient for Sep. Burn		0.7	
30:20	Sep. Burn	$\Delta Vel \approx 2$ fps			7.2	
			SUBTOTAL		(526.6)	
30:30	Power Down	Same as Previous		SCS ~ 4.2db	2.4	
38:30	Post Rendezvous Tracking	Align IMU Orient 3 axis @ 0.2°/sec MI	P51, 52 Observe S-IVB @ 80n.mi.		1.4 1.0	P 1.10
44:30	Same as above	Same as above	Observe S-IVB @160n.mi.		2.4	P 1.10
52:00	Same as above	Same as above	Observe S-IVB @320n.mi.		2.4	P 1.10

TABLE I.- SM RCS EVENT TIMELINE - Continued

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
	COAS Calibration	1-3 axis			0.7	P20.20
			SUBTOTAL		(595.2)	
		Align IMU	P51, P52		1.4	P 1.6
96:10	Midcourse Nav. Sighting	Orient 3 axis @ 2°/sec & MI for 9 marks/each astronaut	P23, Star-Lunar Landmark		1.8	P 1.15
		3 axis maneuver & MI	Lunar horizon/star technique		1.8	P 1.15
96:20	Window Visibility Test	Align IMU Orient 3 axis @ .2°/sec 0.5°/sec pitch & yaw			1.4 0.7 1.8	S20.16
97:20	Power Down	Same as Previous		SCS ~ 4.2°db	2.4	
118:10		IMU Align	P51, P52		1.4	
	SCS Att. Ref. Align	2-3 axis/wide db hold & MI	Drive euler angle to zero & rotate		1.8	P 1.9
		1-1 axis @ .2°/sec	S/C to star yaw to 2nd star		0.4	
		Ullage 2 jets yaw, 20 sec $\Delta V \approx 6$ fps			14.1	
121:02	4th SPS burn (Min Impulse)	Slosh Test	Same as Previous S/C Wt ≈ 30,300 $I_{xx} \approx 17,480$ $I_{yy} \approx 56,490$ $I_{zz} \approx 56,400$		8.0	
			SUBTOTAL		(632.2)	

TABLE I.- SM RCS EVENT TIMELINE - Continued

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
	IMU Orientation Determination (Star visibility test)	4-3 axis @ 0.2°/sec/40 Min Att hold 5° db	Star count	PGNCS ~ FREE	4.0	P 1.7
			Observations 15 min. prior to sunrise & sunset (SCT-LOS to Sun ∢ ≈ 120°) with IMU aligned			
	IMU Orientation Determination		Same as above (SCT - LOS To Sun ∢ ≈ 70°)		4.0	P 1.7
			Same as above (SCT - LOS To Sun ∢ ≈ 120° cabin light subdued)		4.0	P 1.7
56:00	Power Down	Same as Previous			2.4	
72:00	Landmark and RR Test	Align IMU Orient 3 axis @ .2 sec Establish Orbital Rate/ MI	P51 - P52 Combine Landmark/RR Test at WSMR		1.4	P 6.8
73:40	Orbital navigation	Align IMU, orient 3-axis Est. Orbital Rate/MI, Rev. for each 3 rev.	P52, P22		6.6	P 1.8
80:00	Power Down	Same as Previous		SCS ~ 4.2db	2.4	
93:37	Day light IMU Align	Align IMU Orient for day align Align IMU Orient for SPS burn Ullage 4 jets, 15 sec, ΔVel ≈ 6 fps	P51, P52 P52 P52		1.4 0.7 0.7 0.7 22.0	P 1.6
95:37	3rd SPS (Δt ≈ 15.0 sec)					P 3.14
		Slosh damp test	10 sec after SPS hold 5° db 10 min.		8.0	S20.17

TABLE I.- SM RCS EVENT TIMELINE - Continued

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
		Orient for Trim			0.7	
	RCS Trim	$\Delta V \approx 3$ fps			12.3	
	COAS Calibration	1-3 axis			0.7	
123:00	Passive Thermal Control	Align, IMU, Orient, Att. Hold 10 min, Roll 0.3°/sec	P52, Monitor Vehicle Attitude & Rates	PGNCS ~ AUTO	2.0	
123:40	Power Down	Same as Previous		SCS ~ 4.2°db	2.4	
142:30	Landmark Tracking/ RR Test	Align IMU 3 axis orientation Establish Orbital Rate/MI, (3 orbits)	P51, P52 P22 Same as 73:40 except do not re-align IMU on night pass	PGNCS	1.4 0.7 3.8	P 6.8
148:40	Power Down	Same as Previous		SCS ~ 4.2°db	2.4	
166:45	Align IMU	2-3 axis	P51, P52		1.4	
168:15	Align IMU	1-axis Orient for SPS burn/ att hold Ullage 2 jets, 20 sec, ΔVel 6 ≈ fps	P52		0.7 1.2 14.1	
	5th SPS Burn ($\Delta t \approx 57$ sec)					P 2.5
	Slosh Damp Test	Same as Previous	Current Wt ≈ 26,700 $I_{xx} \approx 15{,}000$ $I_{yy} \approx 46{,}600$ $I_{zz} \approx 46{,}400$		8.0	

TABLE I.- SM RCS EVENT TIMELINE - Continued

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
	COAS Calibration	1-3 axis			0.7	P20.20
			SUBTOTAL		(684.7)	
172:20	SPS Cold Soak	Orient & Hold Wide db 1 hr.	+X axis toward sun		3.6	P 7.22
177:15	Power Down	Same as Previous			2.4	
210:25		Align IMU	P51, P52		1.4	
212:00		Align IMU	P52		0.7	
		Orient for SPS burn & att. hold			1.2	
	6th SPS burn(min. impulse	Ullage 2 jets yaw, 20 sec			14.1	
			Damp shutdown transient		1.1	
	COAS Calibration	1-3 axis			0.7	P20.20
			SUBTOTAL		(709.9)	
		Align IMU	P52		0.7	
214:40	Passive Thermal Control	Same as Previous (123:00 hours)		PGNCS ~ AUTO	2.0	
	IMU Orientation determination	Same as at 52:00 hrs	Optical Degradation (If SCT-LOS to sun angle ≈ 120° for 15 min view)		4.0	P 1.7
217:00	CM/RCS Thermal control	Orient, att. hold wide db 1 hr.	+X axis toward sun		3.6	P 7.23

TABLE I.- SM RCS EVENT TIMELINE - Concluded

g.e.t., hr:min	Event	Required maneuver	Comments	Control mode	Propellant, lb	DTO
220:00	Power Down	Same as Previous			2.4	
234:00	Align IMU	2-3 axis	P51, P52		1.4	
236:00		Align IMU	P52		0.7	
		Orient for SPS burn & att. hold			1.2	
		4 jet ullage $\Delta t \approx 15$ sec			22.0	
236:43	7th SPS burn ($\Delta t \approx 20$ sec)	Orient			0.7	
		Post Burn Trim, $\Delta V \approx 2$ fps			5.8	
		Slosh Damp Test			8.0	
	COAS Calibration	1-3 axis			0.7	
			SUBTOTAL		(763.1)	
238:00	Raditor Test	Orient & Hold Wide db	$4\frac{1}{2}$ hr att. hold/ One Raditor Panel Toward Earth	SCS	7.4	M 7.19
242:00	Power Down	Same as previous			2.4	
255:20	Align IMU	2-3 axis	P51, P52		1.4	
		Align IMU	P52		0.7	
		Orient for SPS Deorbit/Att. Hold			1.2	
		Ullage 4 jets 15 sec			22.0	
258:59	SPS Deorbit ($\Delta t \approx 14$ sec)		Damp shutdown transient		1.1	
259:30	S/C separation	CM/SM Sep. 4 jets -X translation of 10 fps and SM Spin Up			25.9	M 7.20
			TOTAL		825.2	

TABLE II.- SM RCS PROPELLANT AVAILABLE FOR MISSION C

Maximum loaded (65°F), lb	1358
Trapped and unexpelled, lb.	(46)
Loading temperature dispersion, lb.	(28)
Minimum deliverable propellant[a], lb	1284
Total PVT gauging errors[b], lb	(78)
Available for mission planning, lb.	1206
Planned usage, lb	825.
Remaining for back-up deorbit at mission end, lb.	381

[a]320.9 lb/quad consisting of 214.6 lb primary and 106.3 lb secondary.

[b]Includes flight variables and mixture ratio dispersions.

TABLE III.- SM RCS PROPELLANT REQUIRED FOR DETAILED TEST OBJECTIVES FOR MISSION C

Objective	Title	Propellant, lb
P1.6	IMU inflight alignment (27)	30.8
P1.7	IMU orientation determination (4)	10.4
P1.8	Orbital navigation/landmark tracking (6)	9.7
P1.9	SCS attitude reference alignment (1)	2.2
P1.10	Sextant tracking[a] (3)	3.0
P1.12	GNCS attitude control	?
P1.13	GNCS ΔV capability[a] (10)	183.0
P1.15	Midcourse navigation (2)	3.6
P2.4	SCS attitude control	?
P2.5	SCS ΔV control	22.0
P2.7	SCS attitude reference checks	NA
P3.14	SPS minimum impulse burn (2)	NA
P3.14	SPS performance evaluation	65.0
P6.8	Overpass simulation/RR (2)	2.1
M7.19	Radiator heat rejection and degradation	7.4
M7.21	SLA deployment system	28.8
P7.22	SPS propellant thermal control	3.6
P7.23	CM RCS thermal control	3.6
P20.8	Separation/transposition/sim. docking	36.7
P20.9	Manual retro-attitude orientation (2)	4.4

[a]Does not include rendezvous

TABLE III.- SM RCS PROPELLANT REQUIRED FOR DETAILED TEST OBJECTIVES FOR MISSION C - Concluded

Objective	Title	Propellant, lb
P20.13	CSM-active rendezvous (TPI to SEP)	264.4
S20.16	Environmental induced window deposits	2.5
S20.17	Propellant slosh damping (4)	32.0
S20.20	COAS evaluation	4.9
Experiments	5005 synoptic terrain photography	NA
	5006 synoptic weather photography	NA

TABLE IV.- SPS PROPELLANT SUMMARY FOR MISSION C

Nominal loading, lb	9081
Residual propellant, lb	(390)
Loading uncertainties, lb	(45)
Mixture ratio allowance, lb	(268)
Nonpropulsive start losses, lb	(115)
Propellant available for ΔV, lb	8263
Planned usage[a], lb	7812
Nominal remaining, lb	451

[a]Based on nominal specific impulse of 313.4 sec.

TABLE V.- MISSION C INITIAL VEHICLE CONDITIONS

	Weight, lb	Center of gravity, in.			Moments of inertia, slug-ft^2		
		X	Y	Z	I_{xx}	I_{yy}	I_{zz}
CM	12 659 $\pm$ 100	1041.2 $\pm$ 1.0	-0.4 $\pm$ 0.5	5.7 $\pm$ 0.5	6023	5 304	4 796
SM	10 800 $\pm$ 100	920.5 $\pm$ 1.0	-6.1 $\pm$ 0.5	10.1 $\pm$ 0.5	7337	11 926	11 451
SLA ring	91	837.1	-0.3	1.9	113	58	55
SPS Propellant	8 930 $\pm$ 44	865.9 $\pm$ 0.3	11.1 $\pm$ 0.3	1.5 $\pm$ 0.3	4337	852	5030

TABLE VI.- MISSION C CONSUMABLES LOADING SUMMARY

SPS propellant, lb	9081.
RCS quad propellant:	
Primary, lb.	823.2
Secondary, lb.	535.2
GOX (CM), lb	3.7
Hydrogen per tank (2 tanks), lb.	28.
Oxygen per tank (2 tanks), lb.	320.
Potable water, lb.	0.
Waste water, lb.	10.

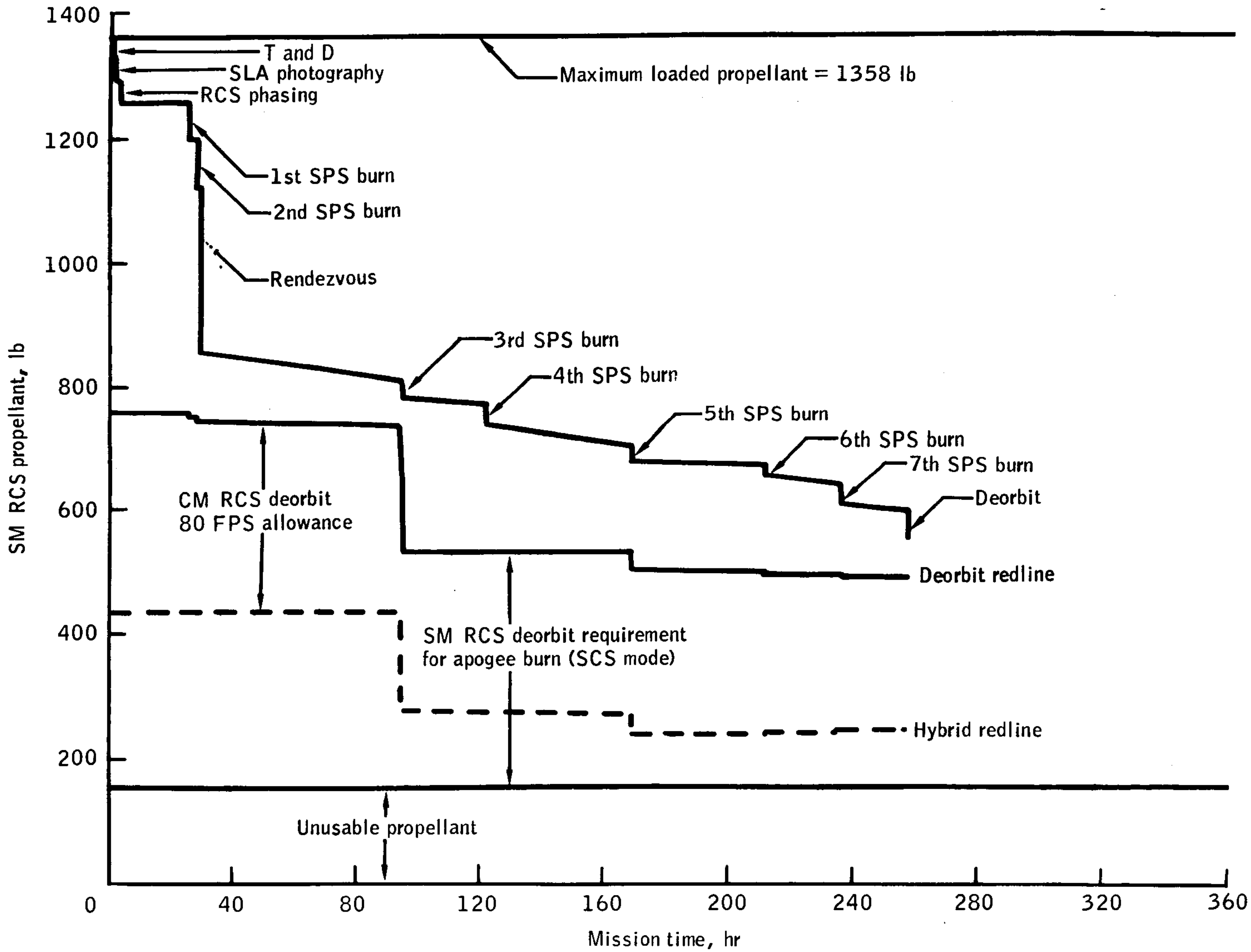


Figure 1.- AS-205/101 SM RCS propellant profile.

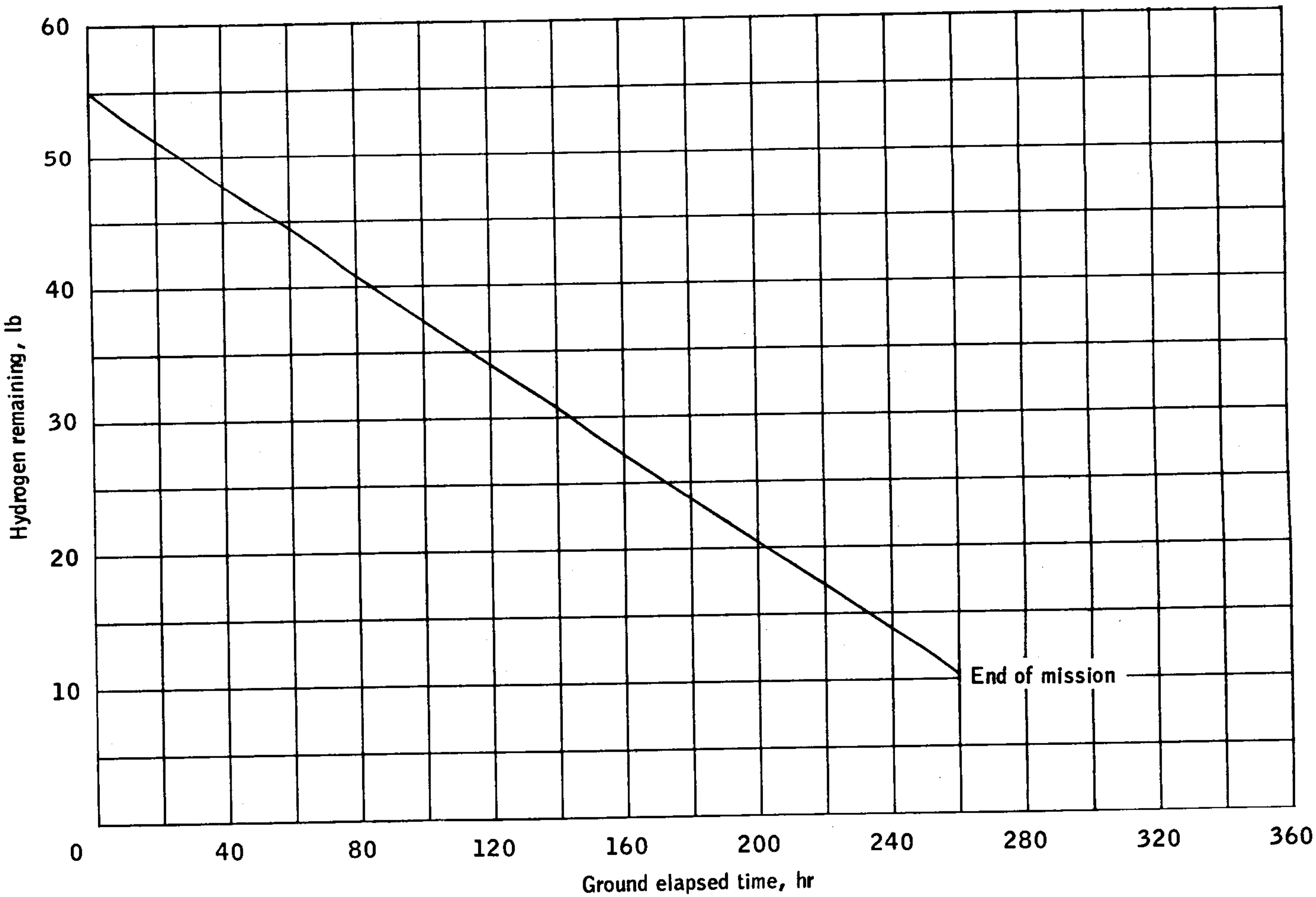


Figure 2.- AS-205/101 hydrogen remaining as a function of mission time.

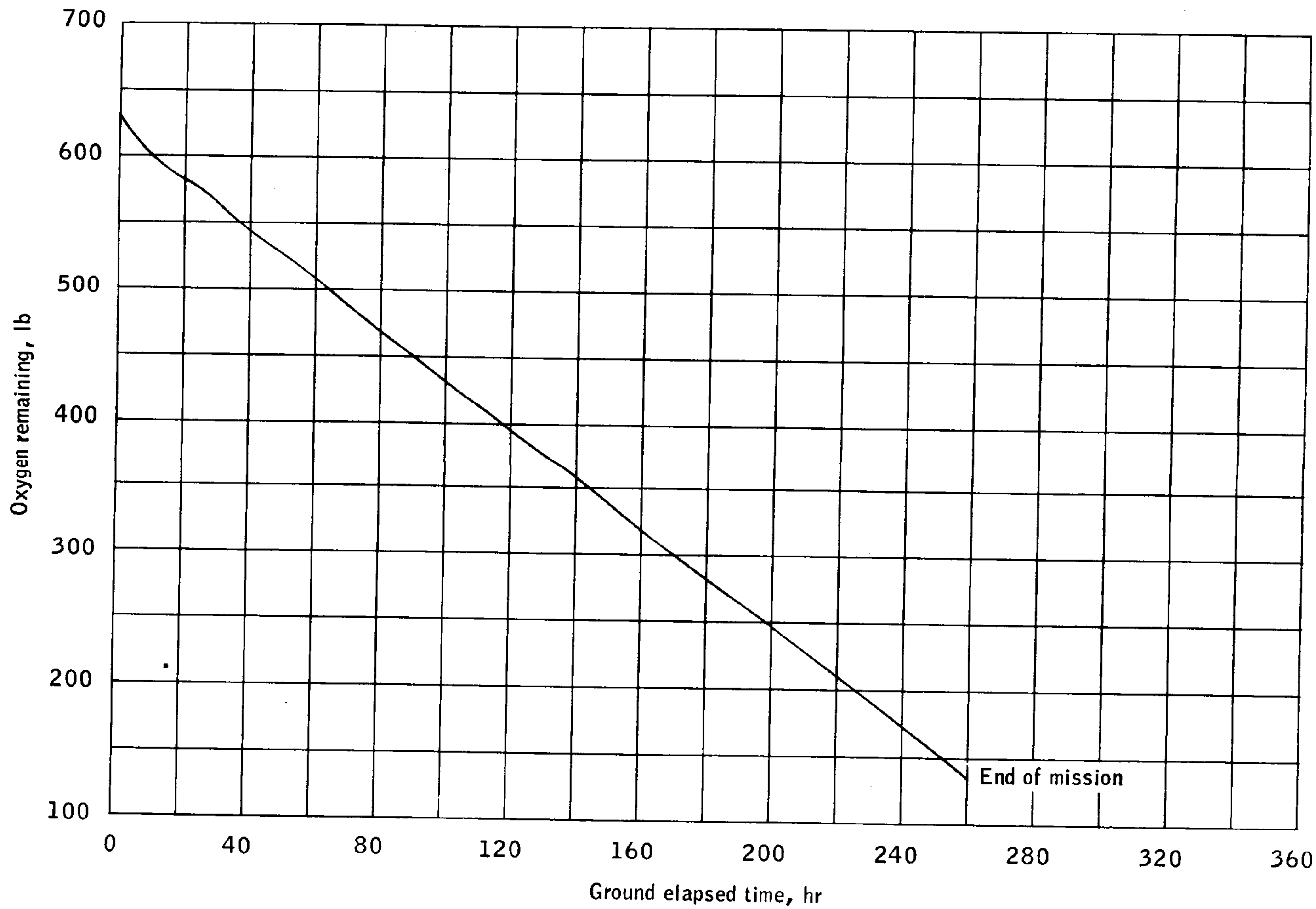
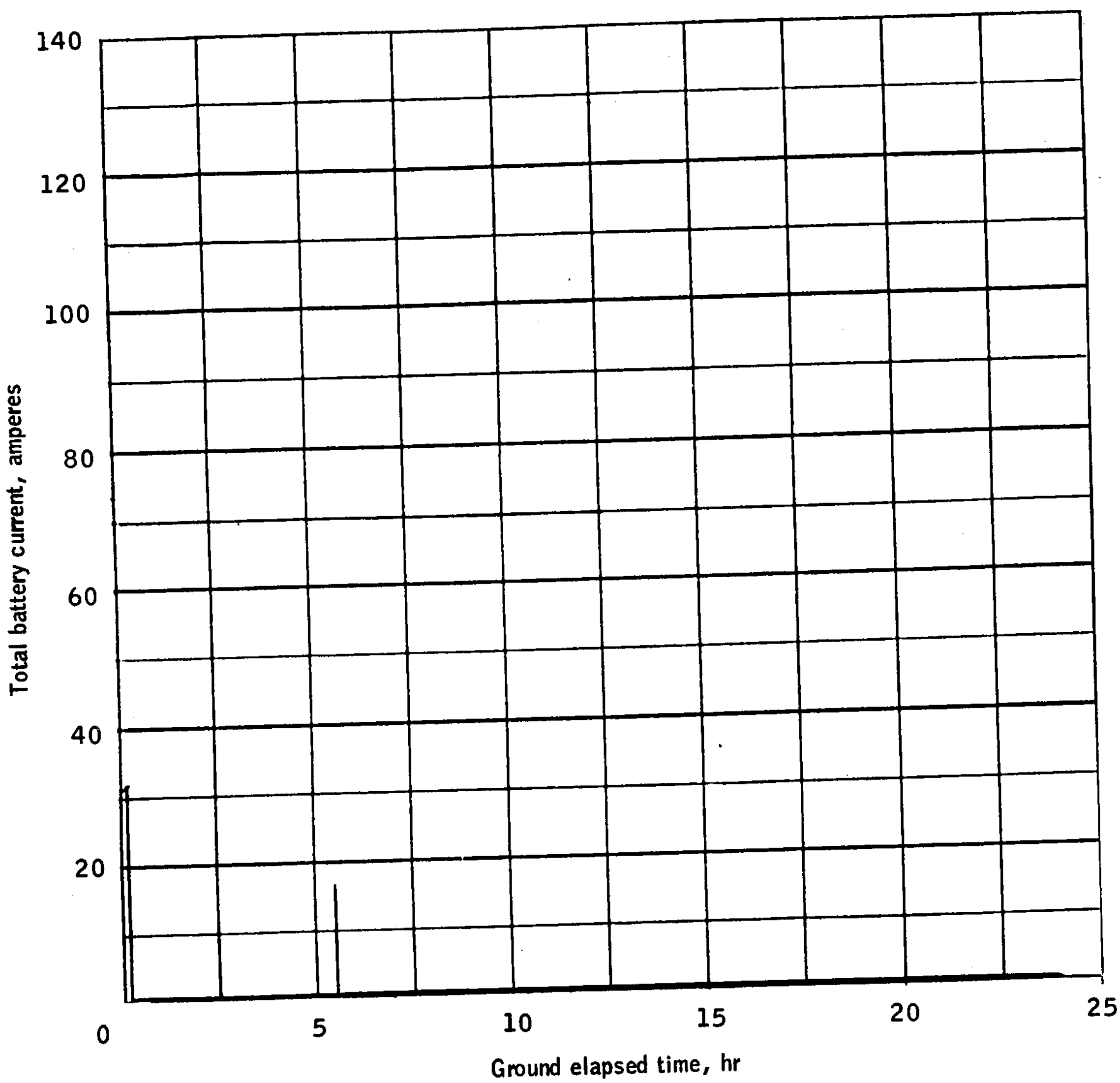
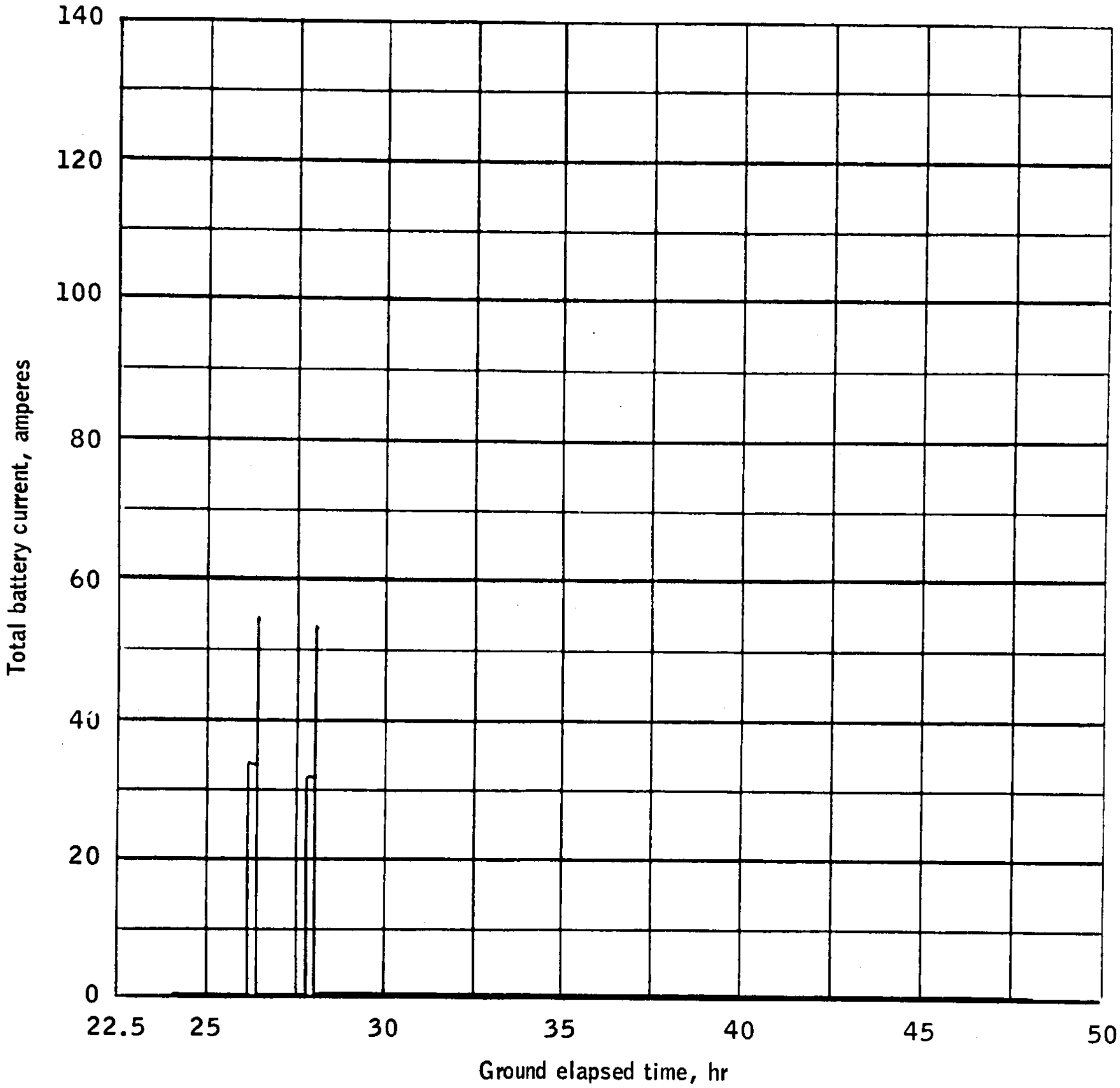


Figure 3.- AS-205/101 oxygen remaining as a function of mission time.



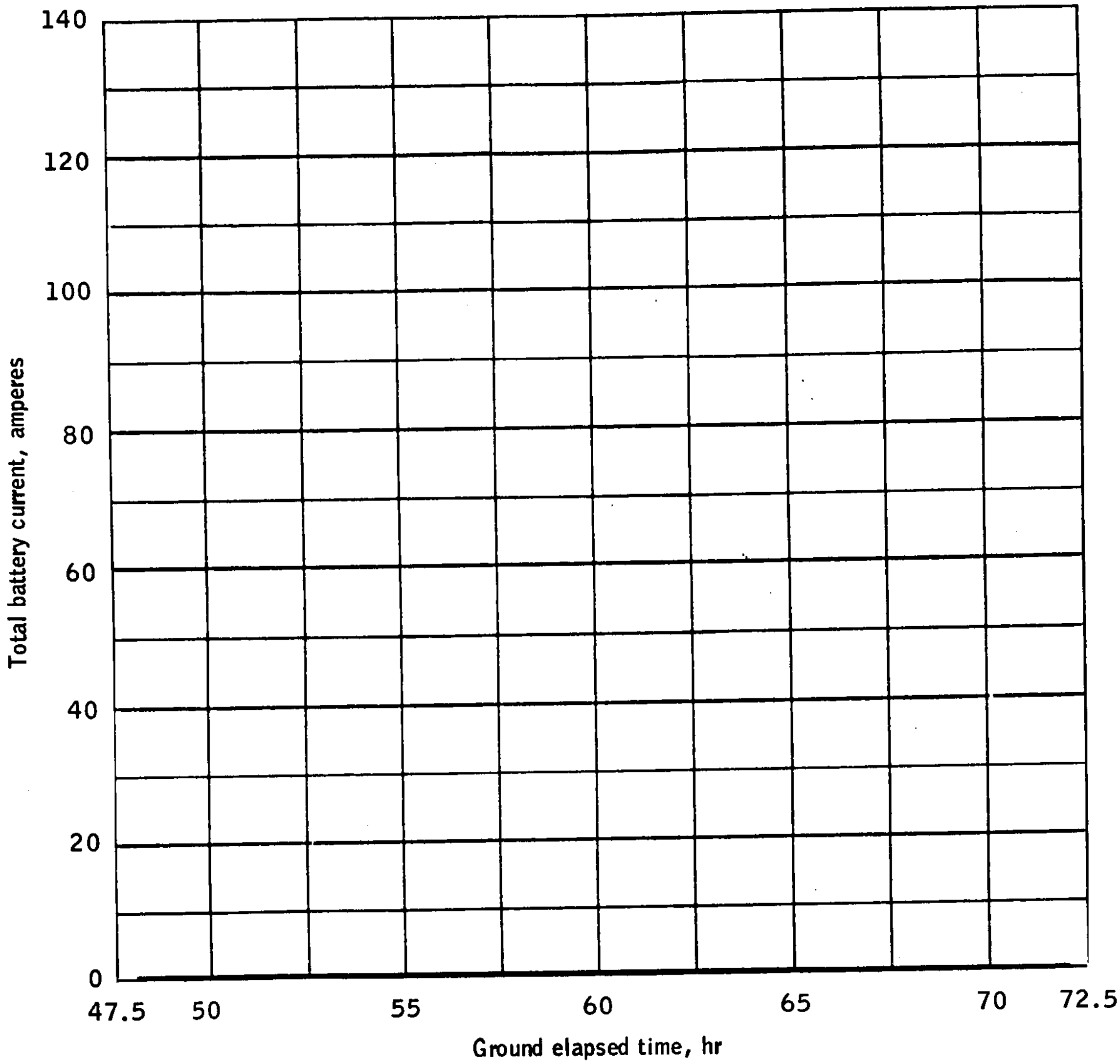
(a) Lift-off to 24 hours, ground elapsed time.

Figure 4.- Time history of total battery current.



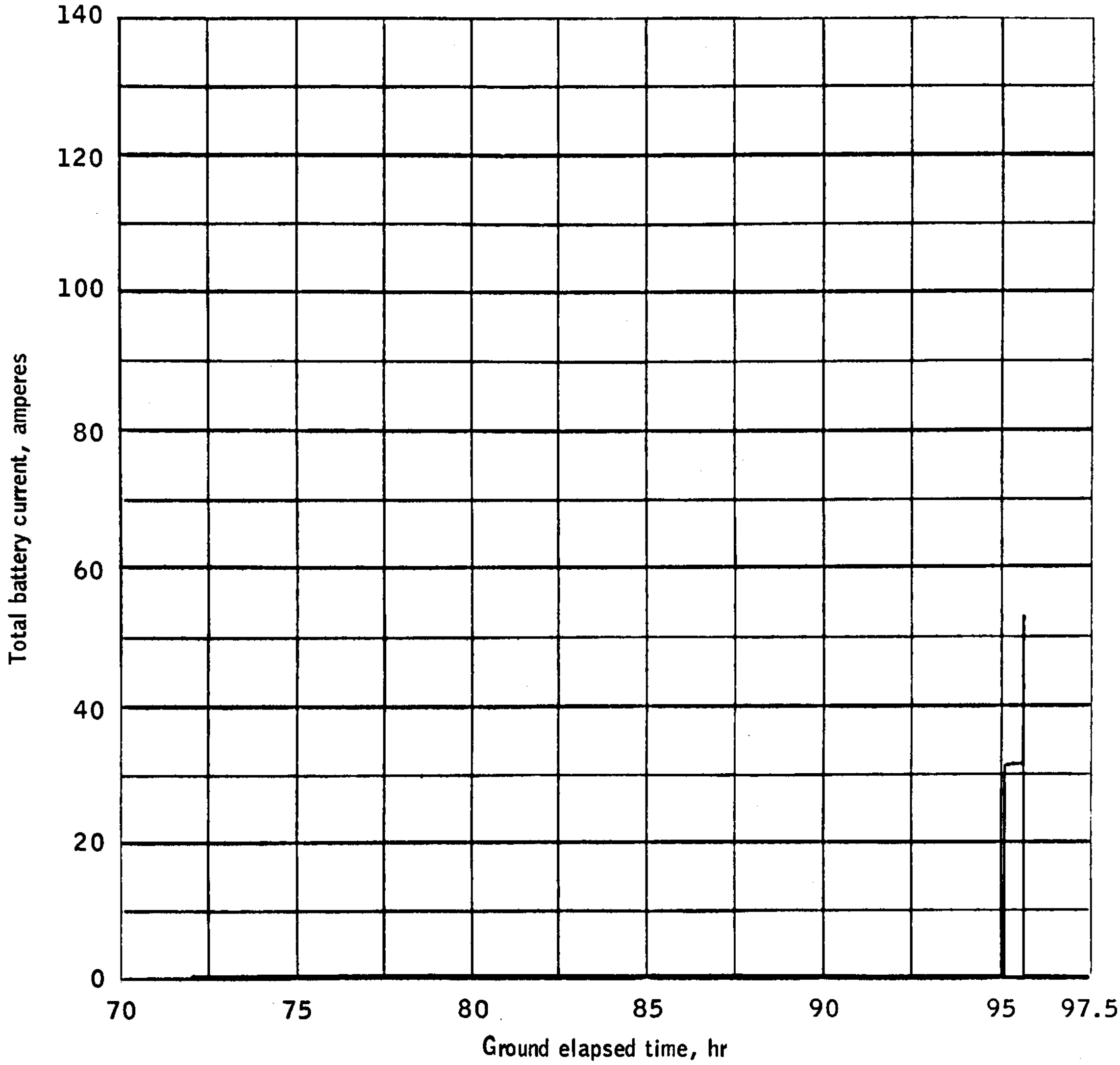
(b) 24 hours to 48 hours, ground elapsed time.

Figure 4.- Continued.



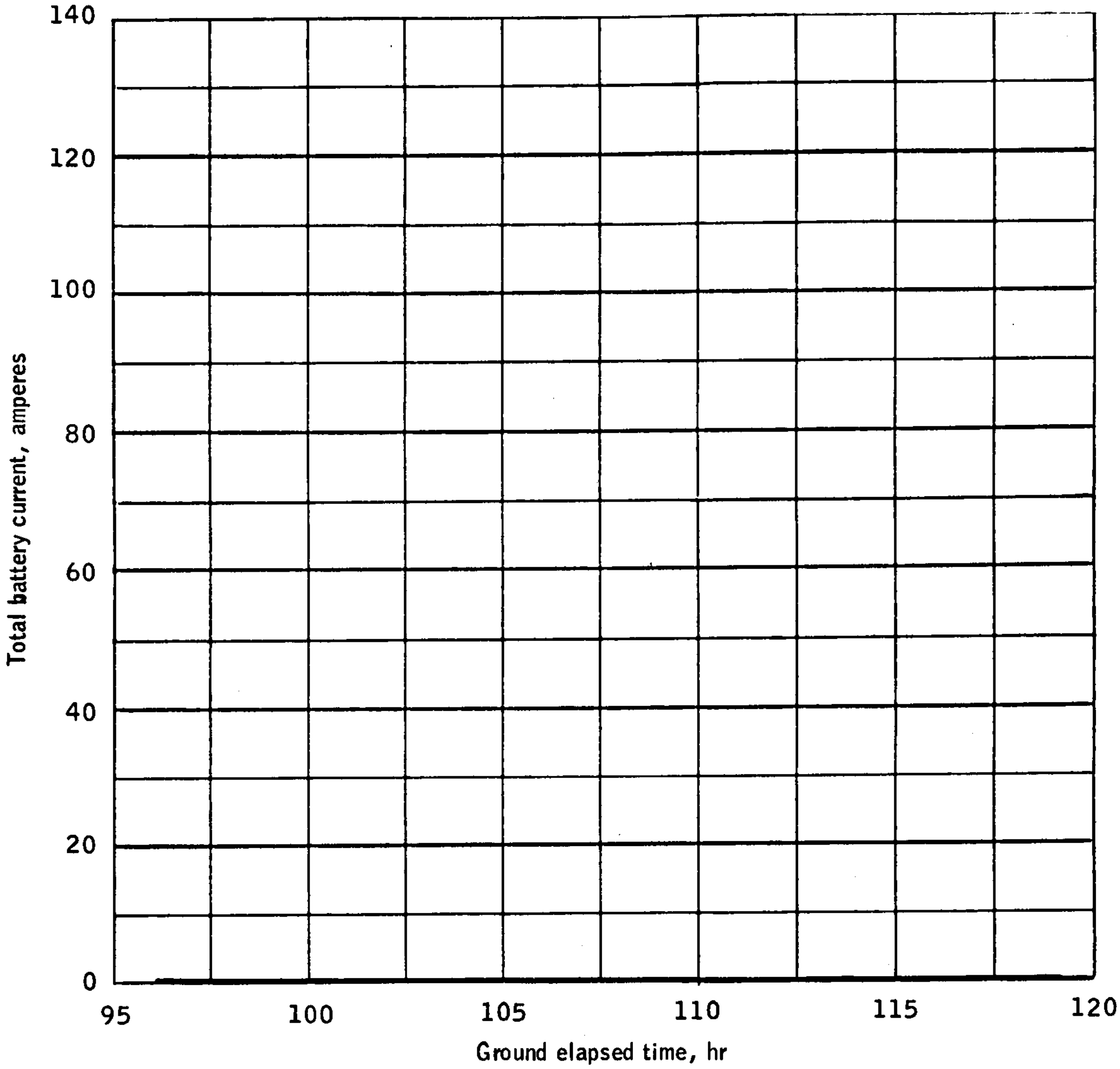
(c) 48 hours to 72 hours, ground elapsed time.

Figure 4.- Continued.



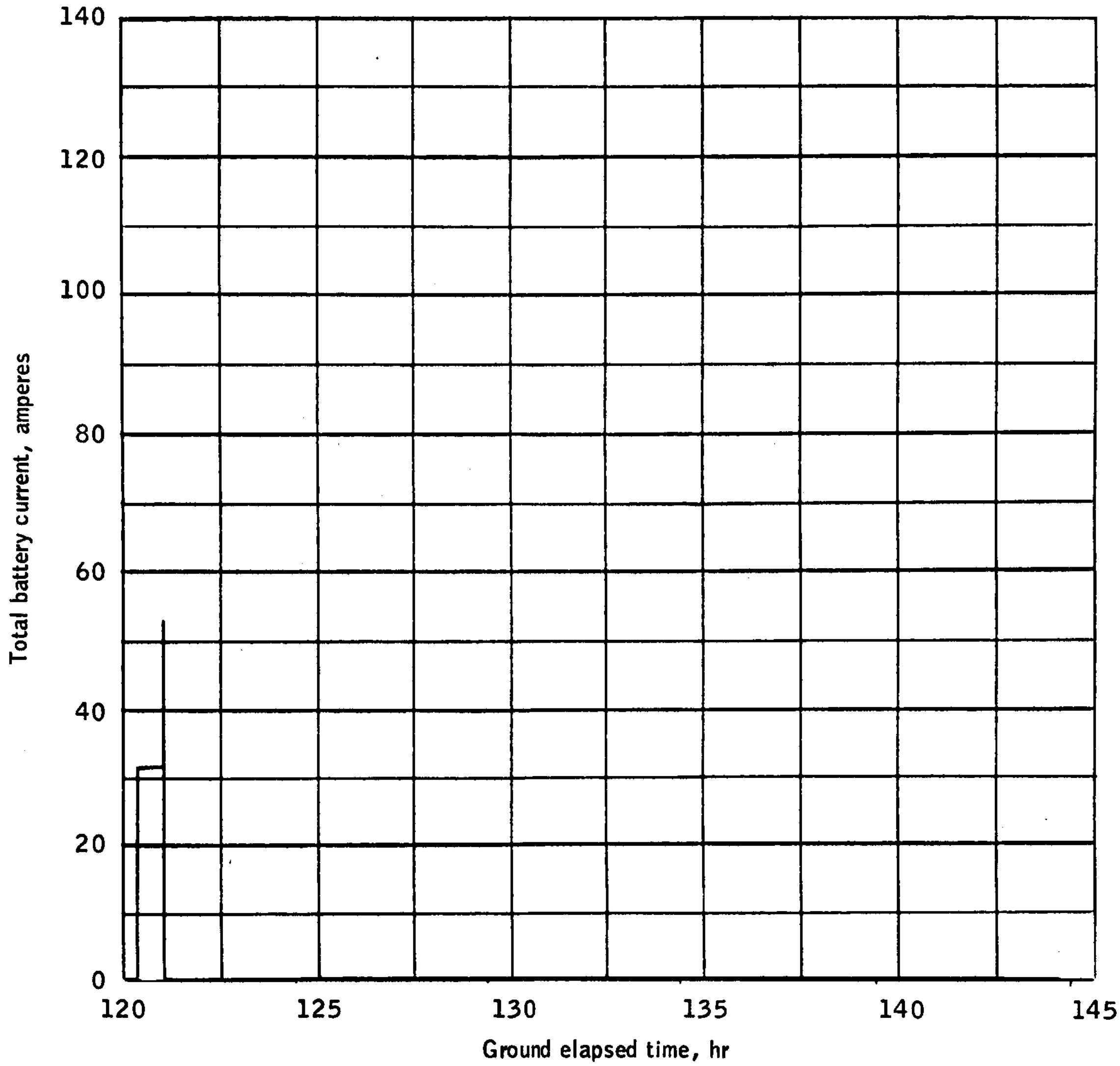
(d) 72 hours to 96 hours, ground elapsed time.

Figure 4.- Continued.



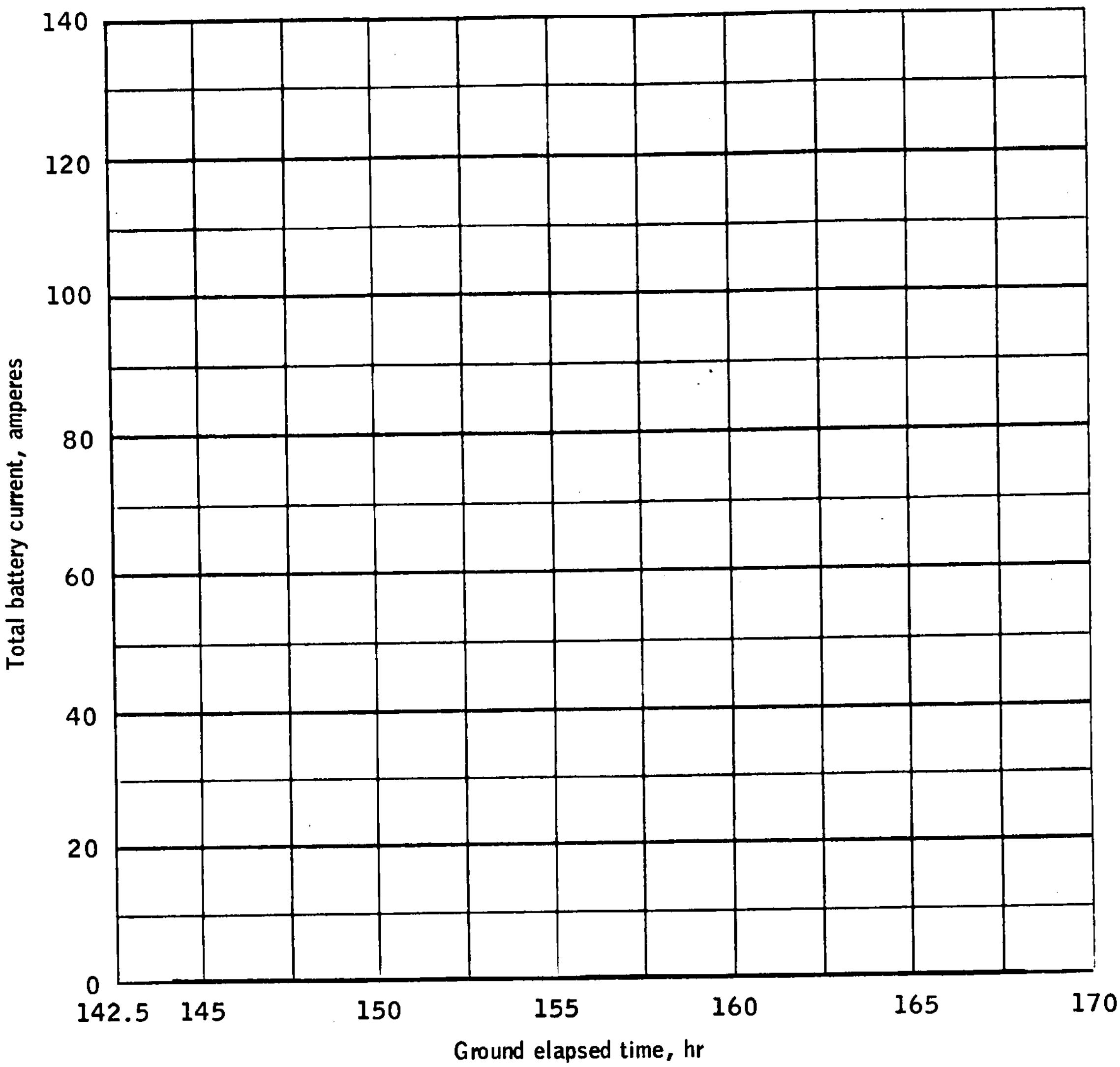
(e) 96 hours to 120 hours, ground elapsed time.

Figure 4.- Continued.



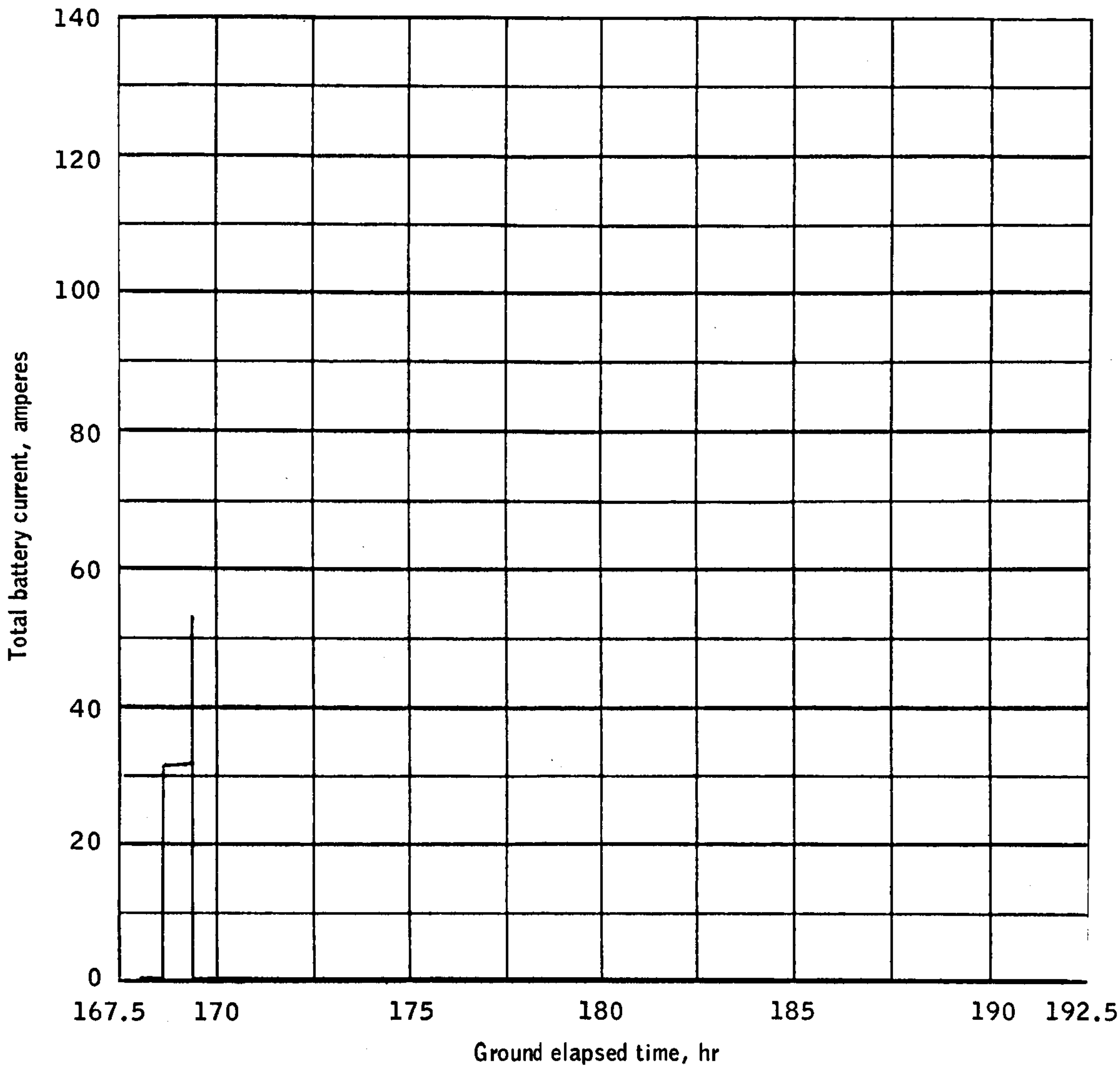
(f) 120 hours to 144 hours, ground elapsed time.

Figure 4.- Continued.



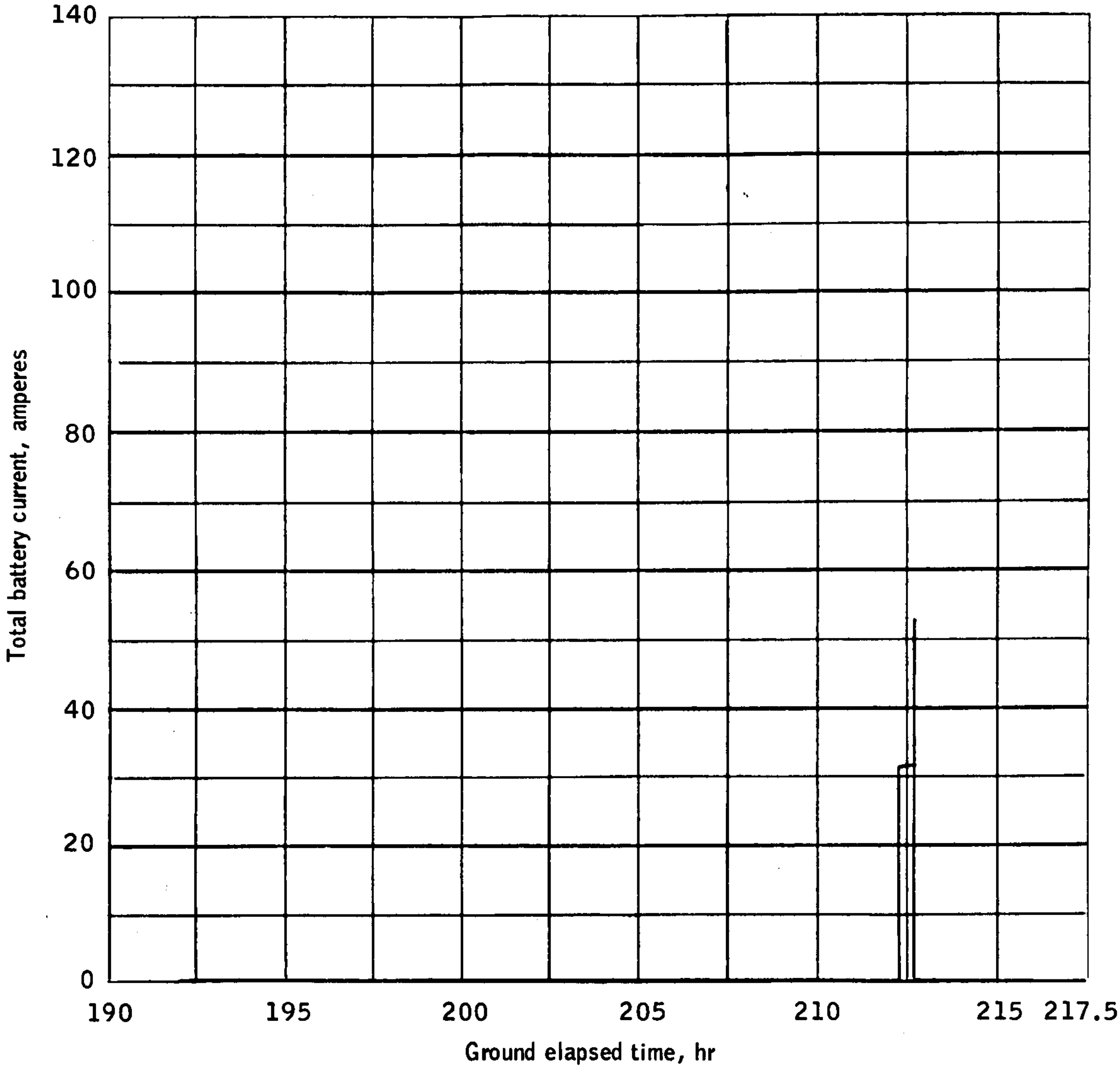
(g) 144 hours to 168 hours, ground elapsed time.

Figure 4.- Continued.



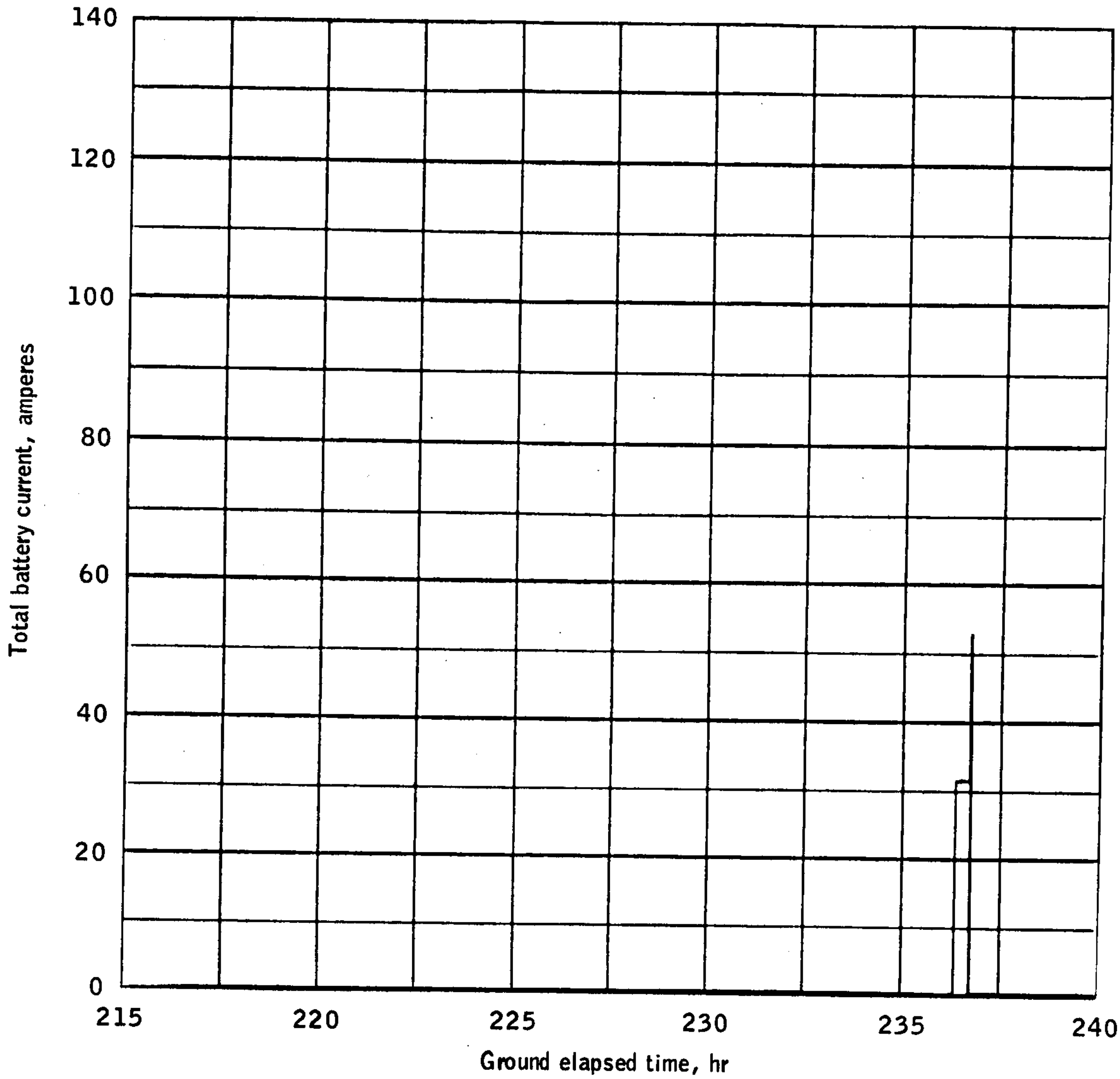
(h) 168 hours to 192 hours, ground elapsed time.

Figure 4.- Continued.



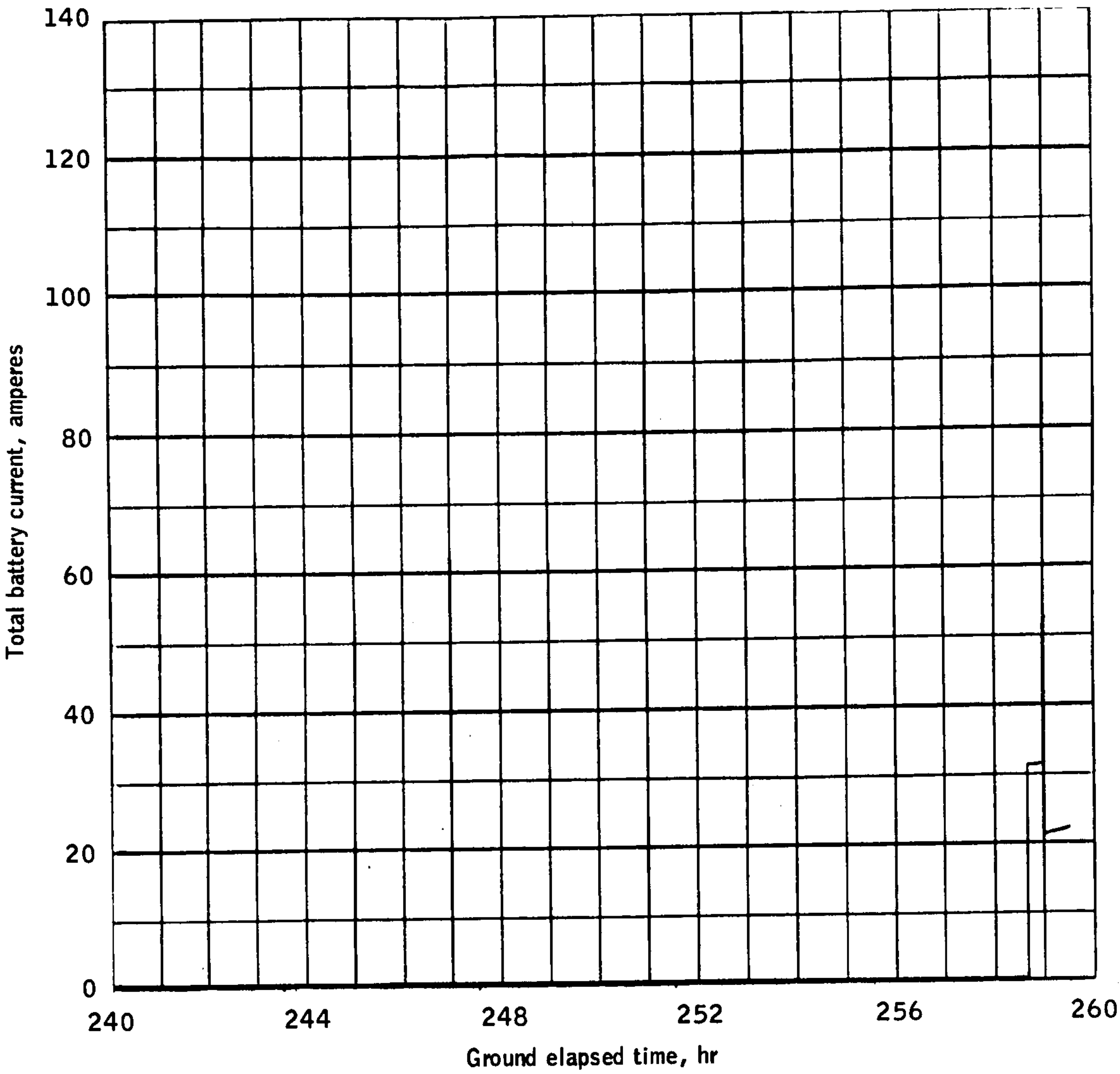
(i) 192 hours to 216 hours, ground elapsed time.

Figure 4.- Continued.



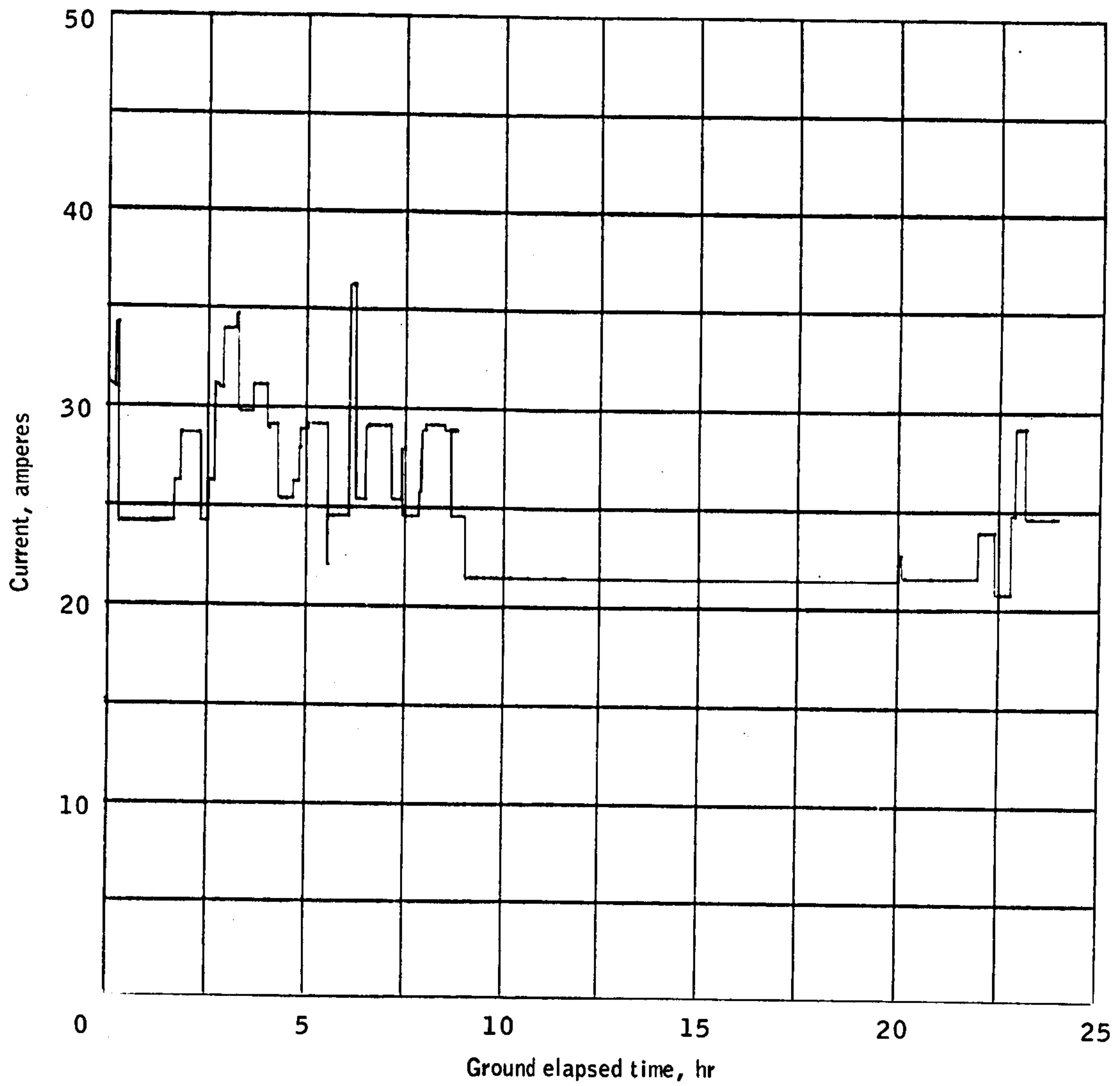
(j) 216 hours to 240 hours, ground elapsed time.

Figure 4.- Continued.



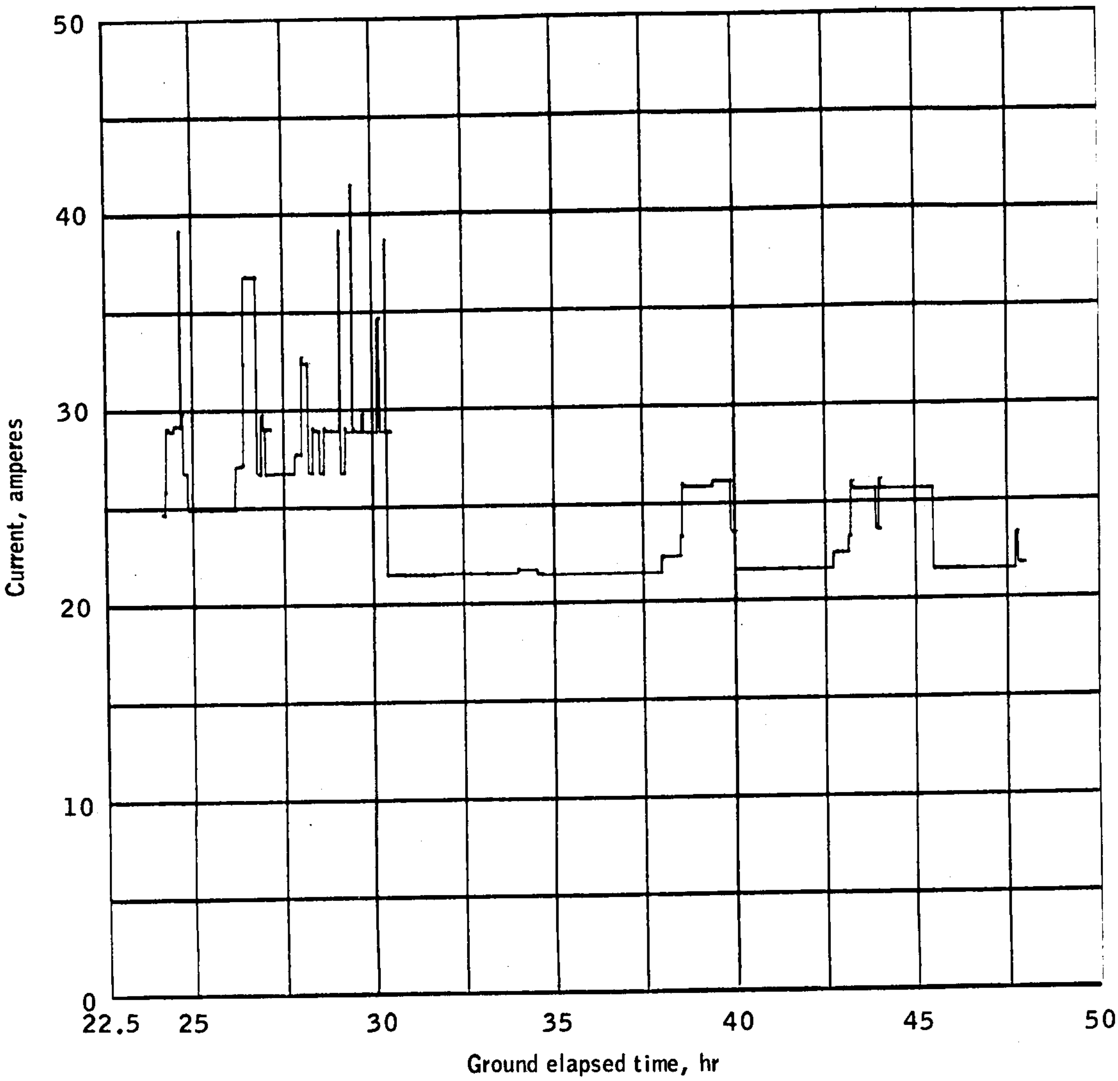
(k) 240 hours to 260 hours, ground elapsed time.

Figure 4.- Concluded.



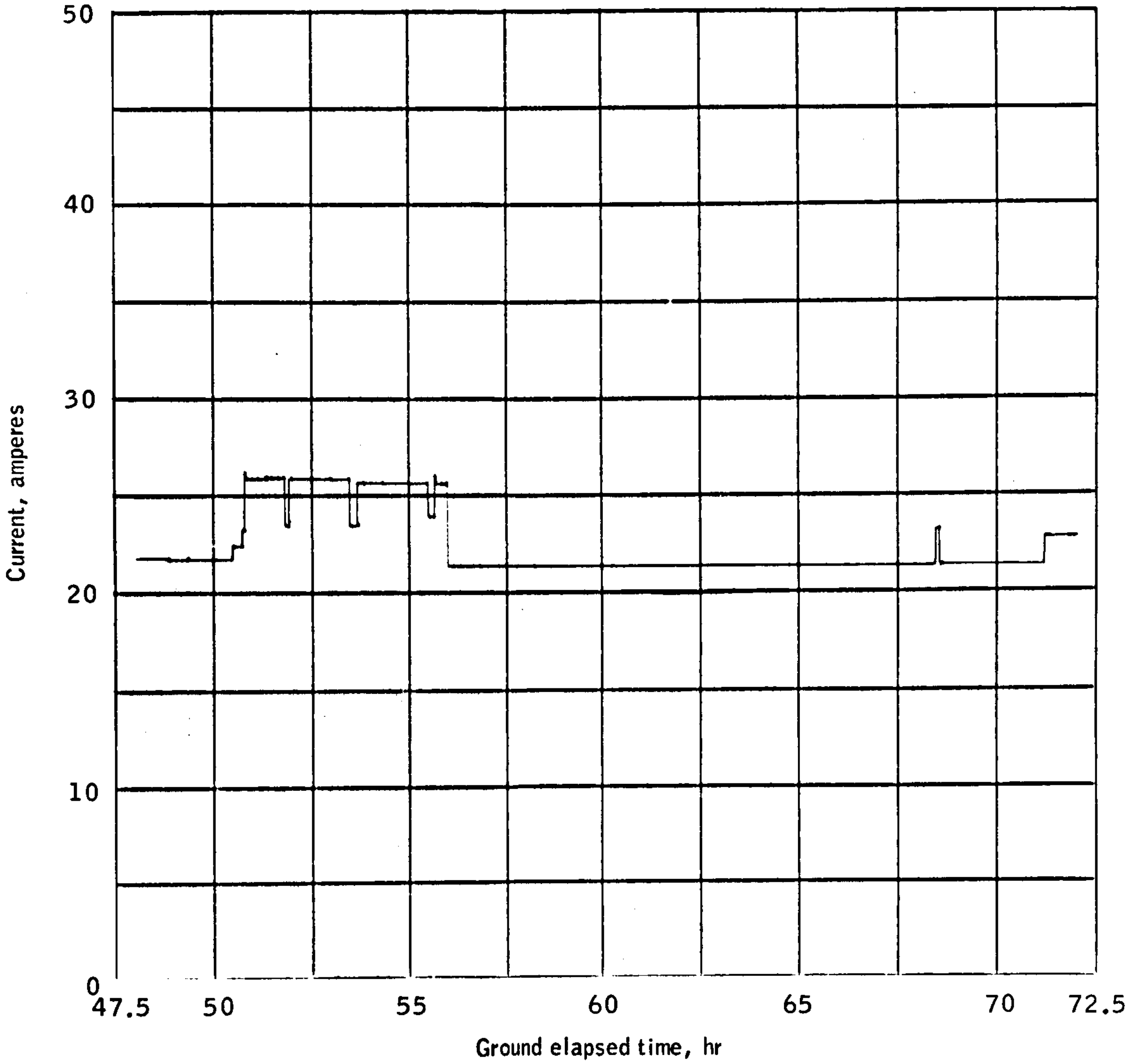
(a) Lift-off to 24 hours, ground elapsed time.

Figure 5.- Time history of fuel cell 1 current.



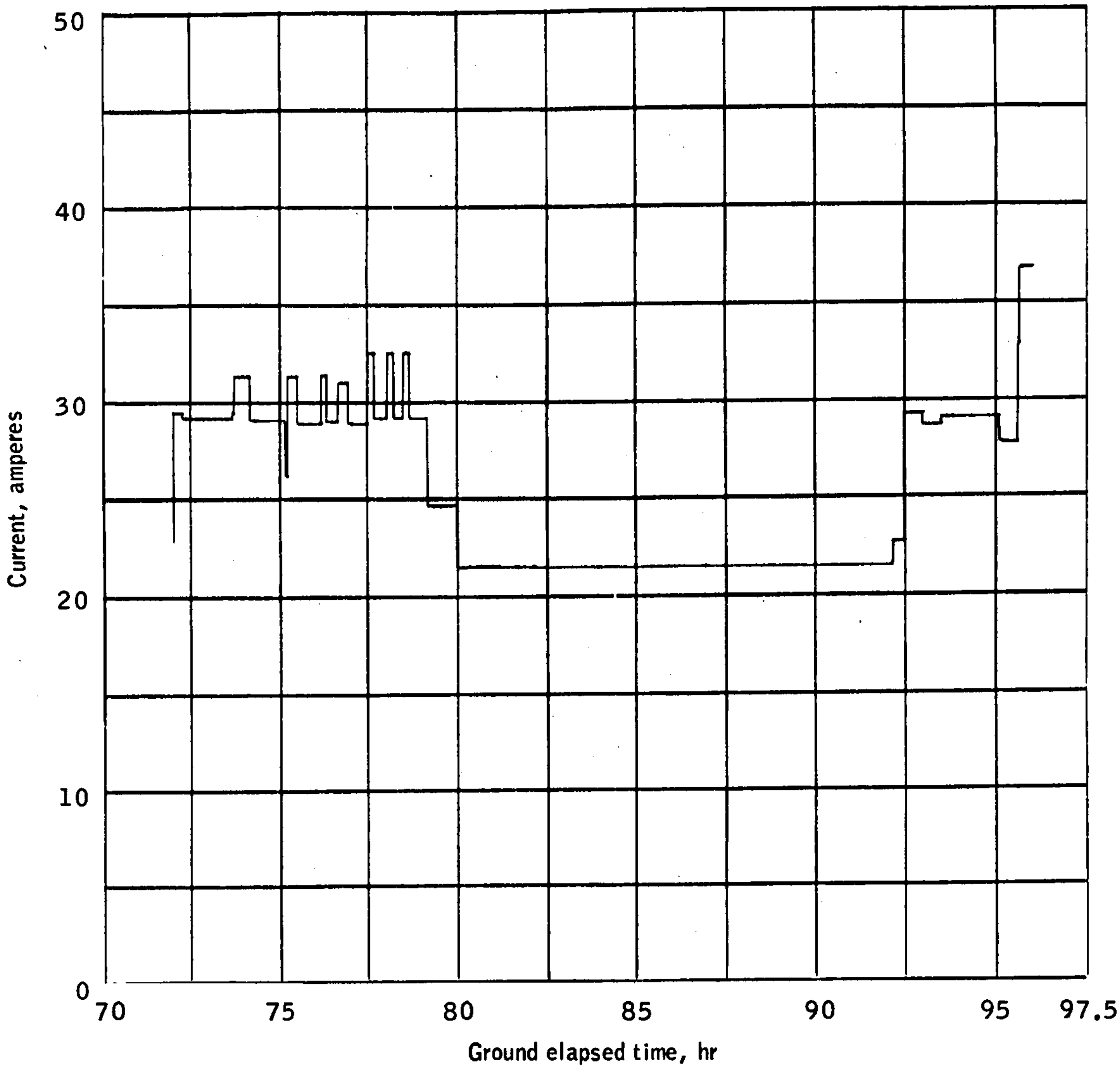
(b) 24 hours to 48 hours, ground elapsed time.

Figure 5.- Continued.



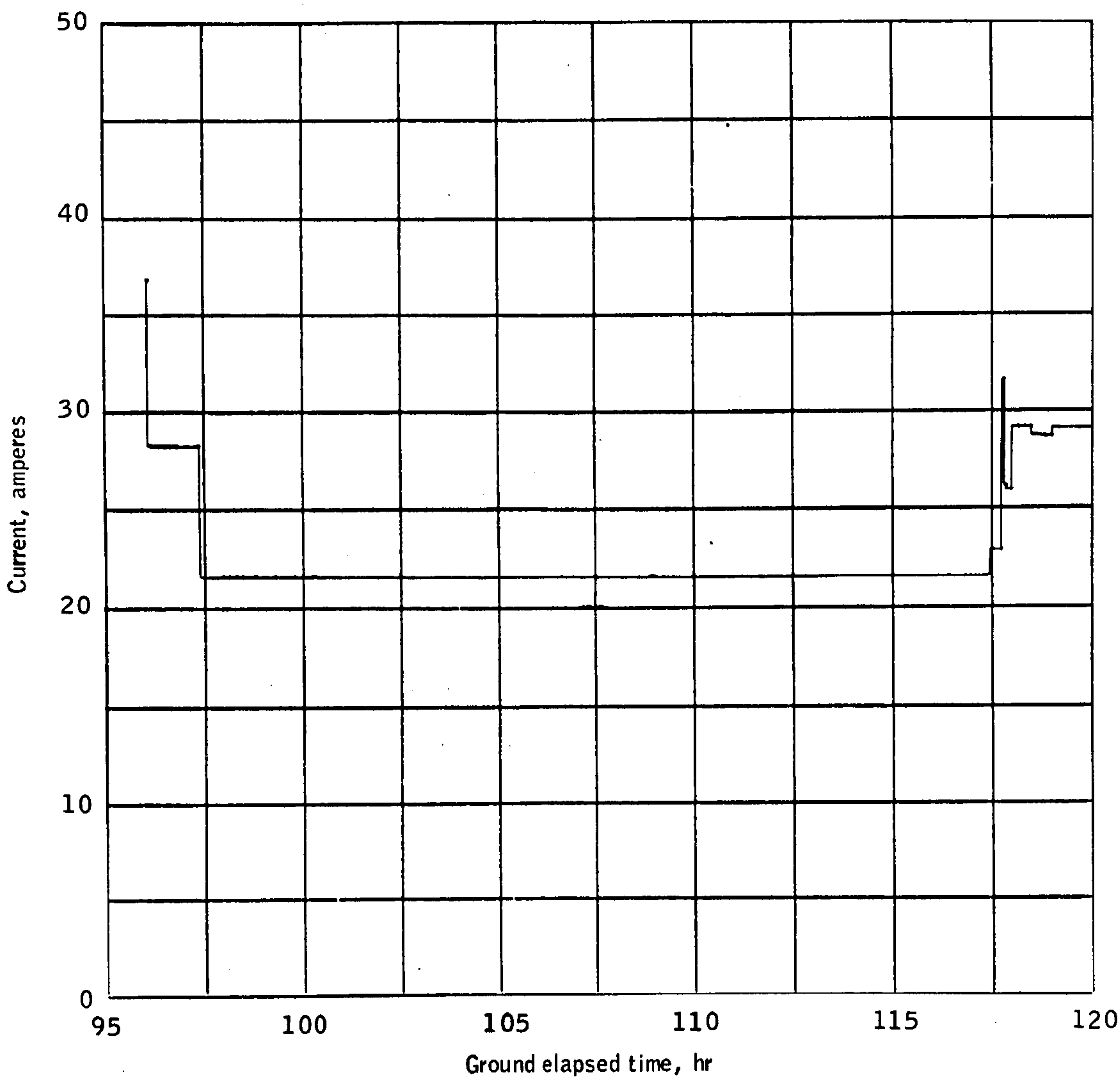
(c) 48 hours to 72 hours, ground elapsed time.

Figure 5.- Continued.



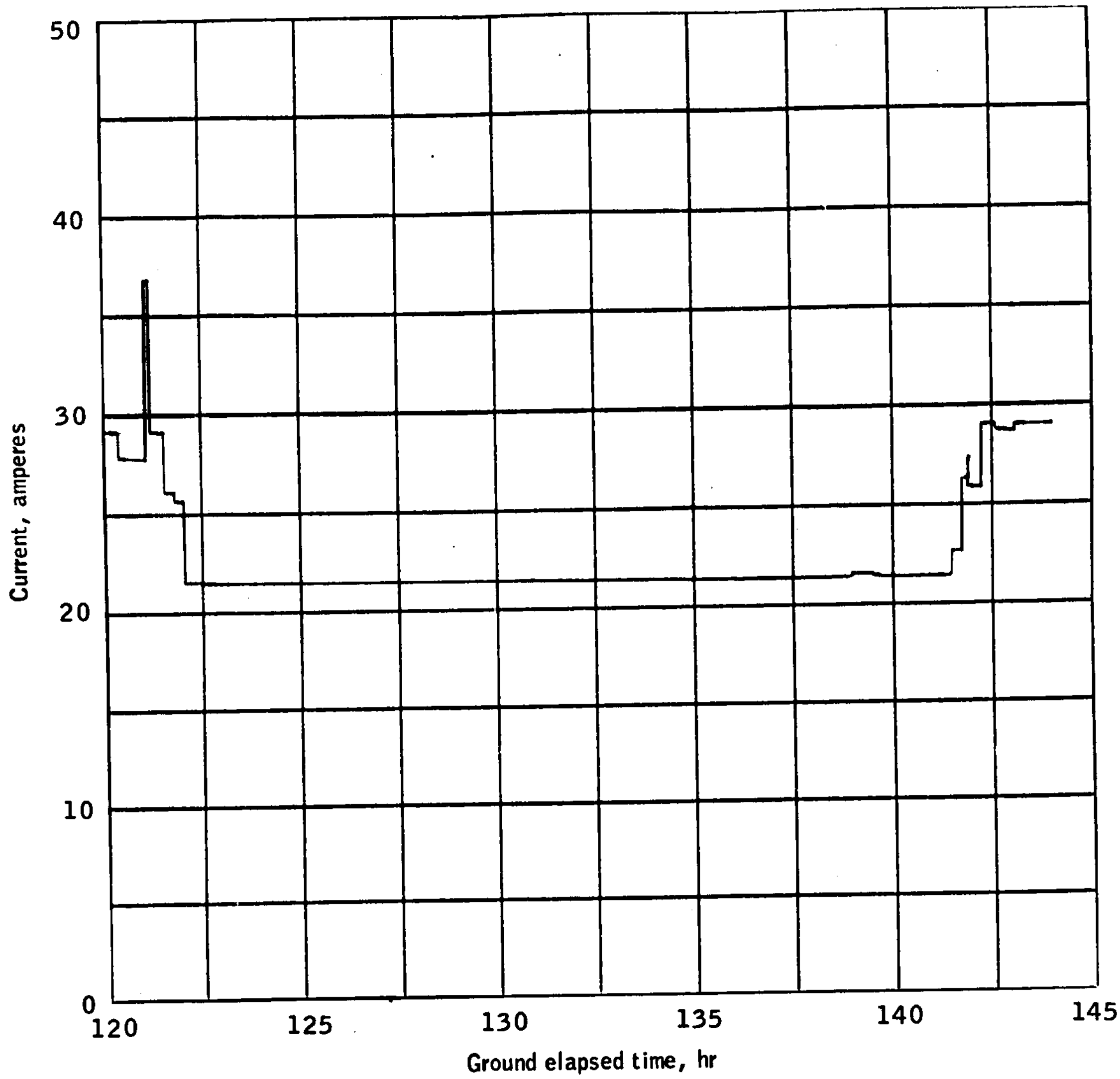
(d) 72 hours to 96 hours, ground elapsed time.

Figure 5.- Continued.



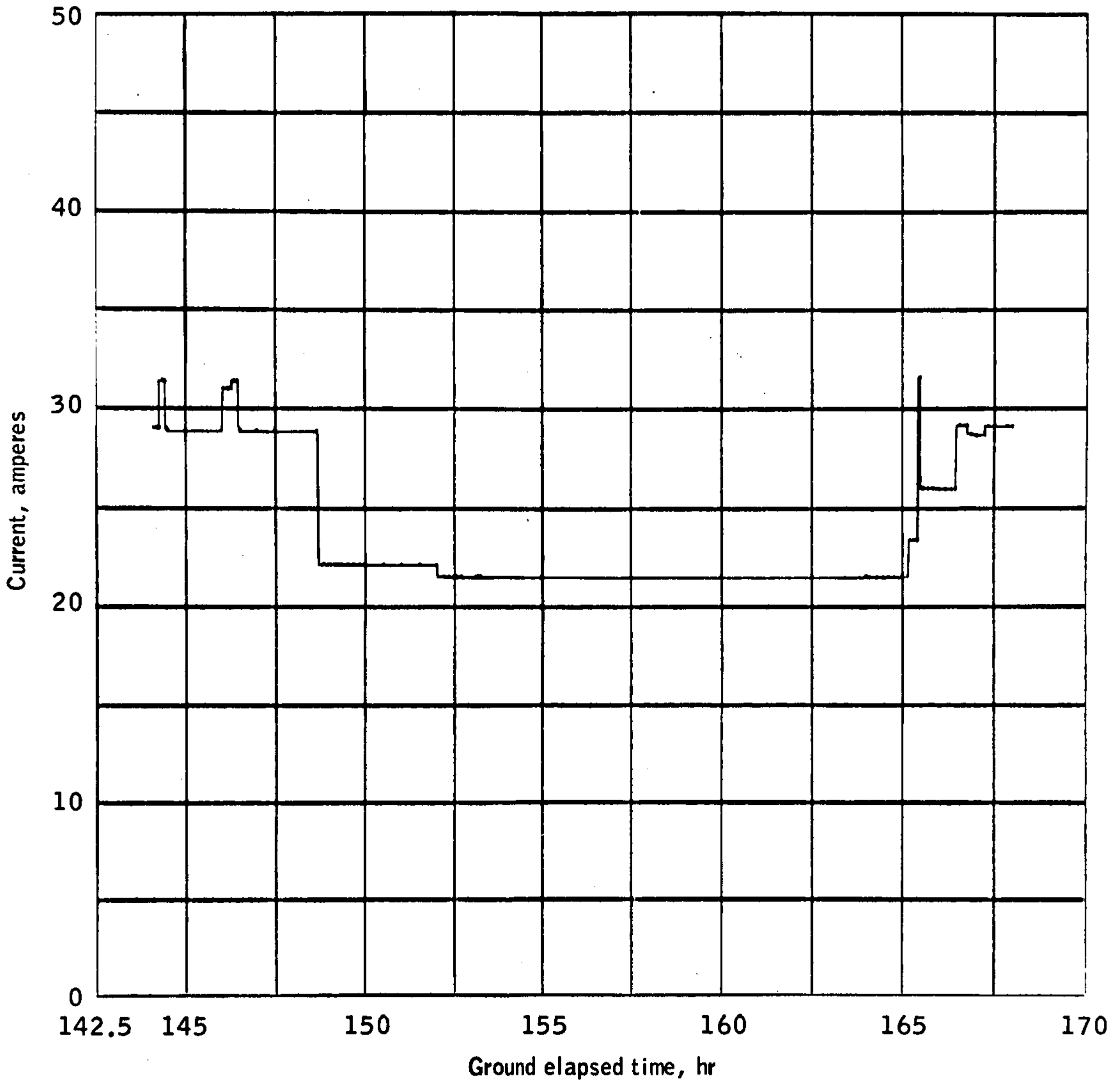
(e) 96 hours to 120 hours, ground elapsed time.

Figure 5.- Continued.



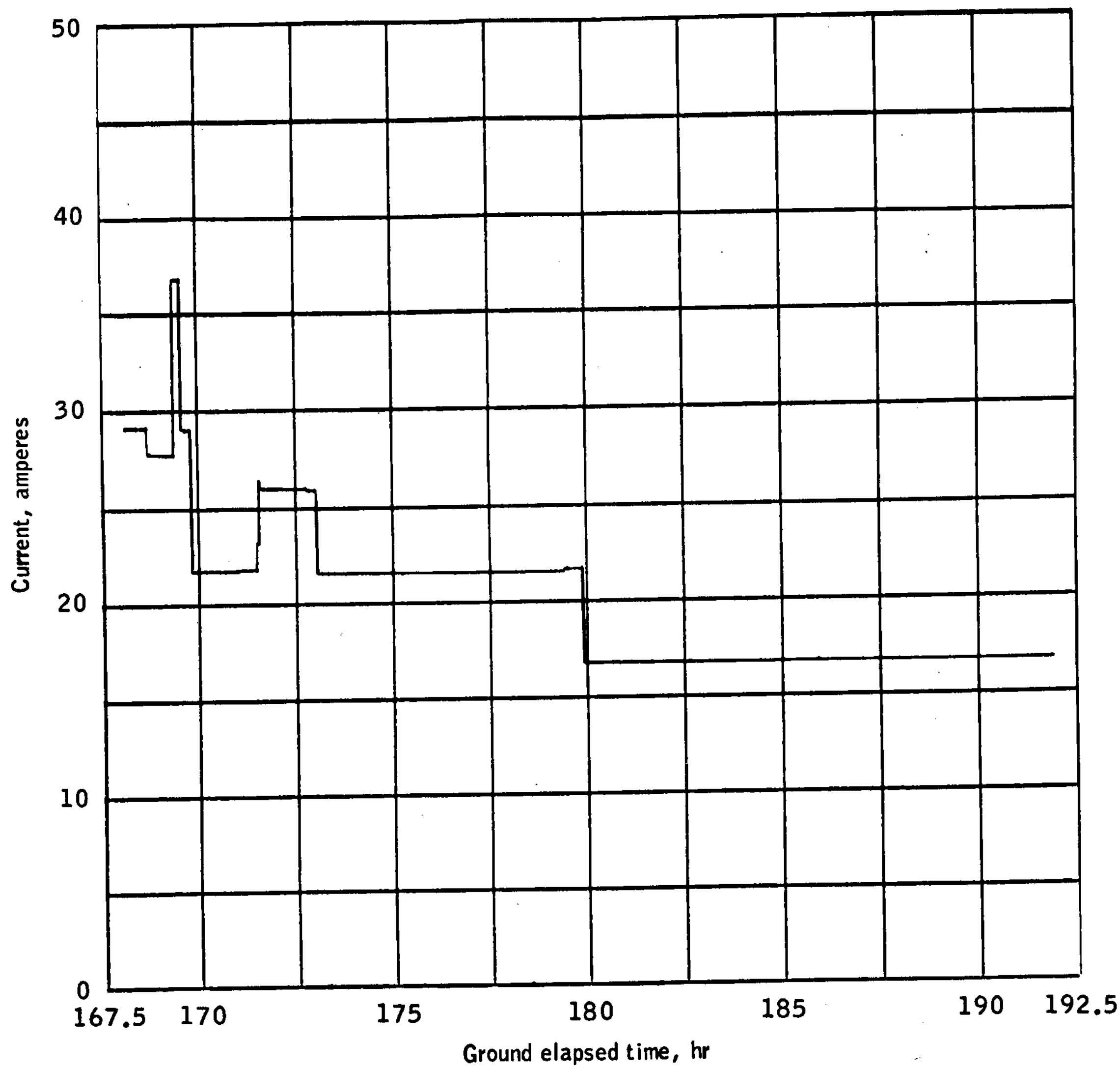
(f) 120 hours to 144 hours, ground elapsed time.

Figure 5.- Continued.



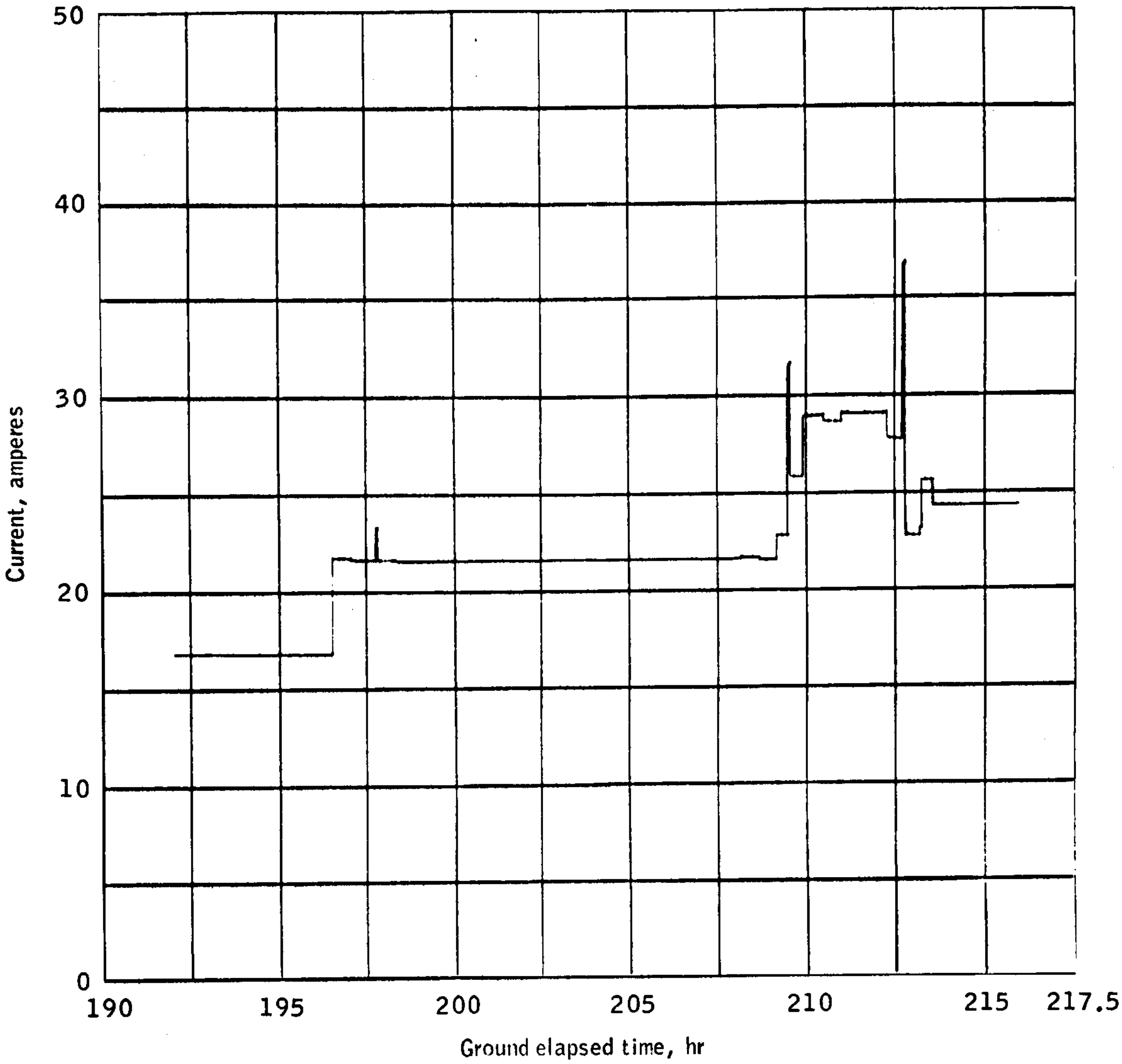
(g) 144 hours to 168 hours, ground elapsed time.

Figure 5.- Continued.



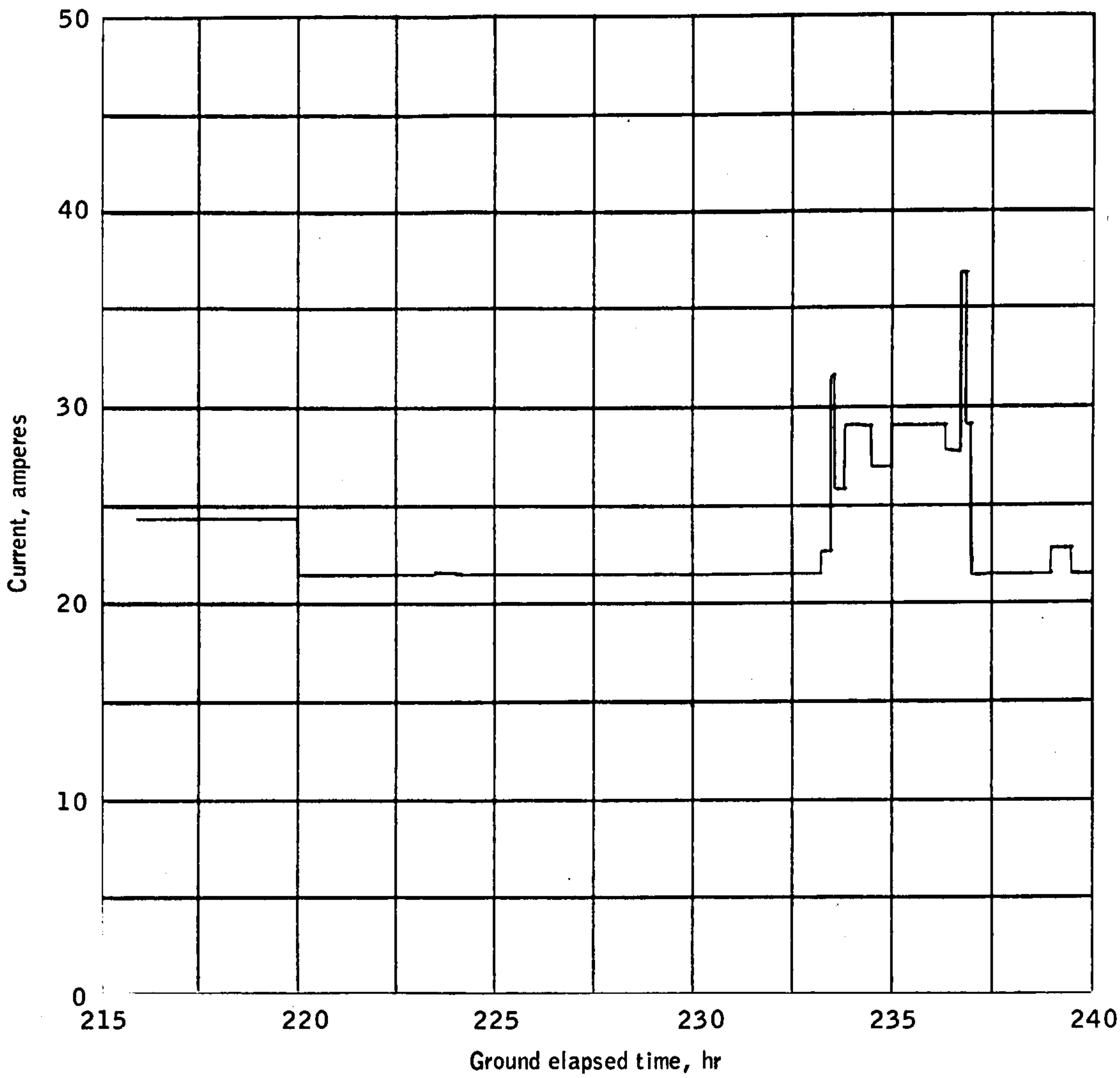
(h) 168 hours to 192 hours, ground elapsed time.

Figure 5.- Continued.



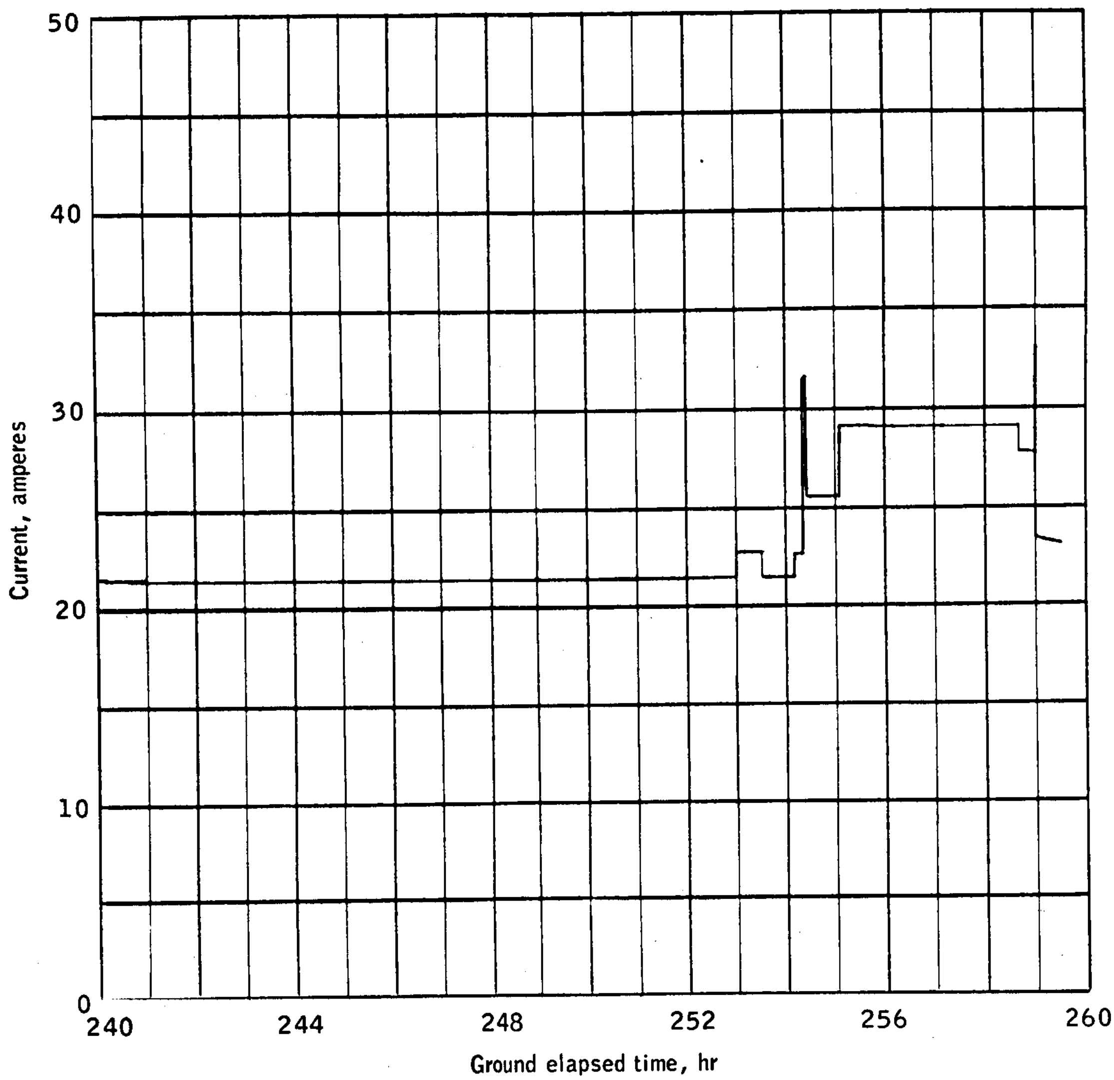
(i) 192 hours to 216 hours, ground elapsed time.

Figure 5.- Continued.



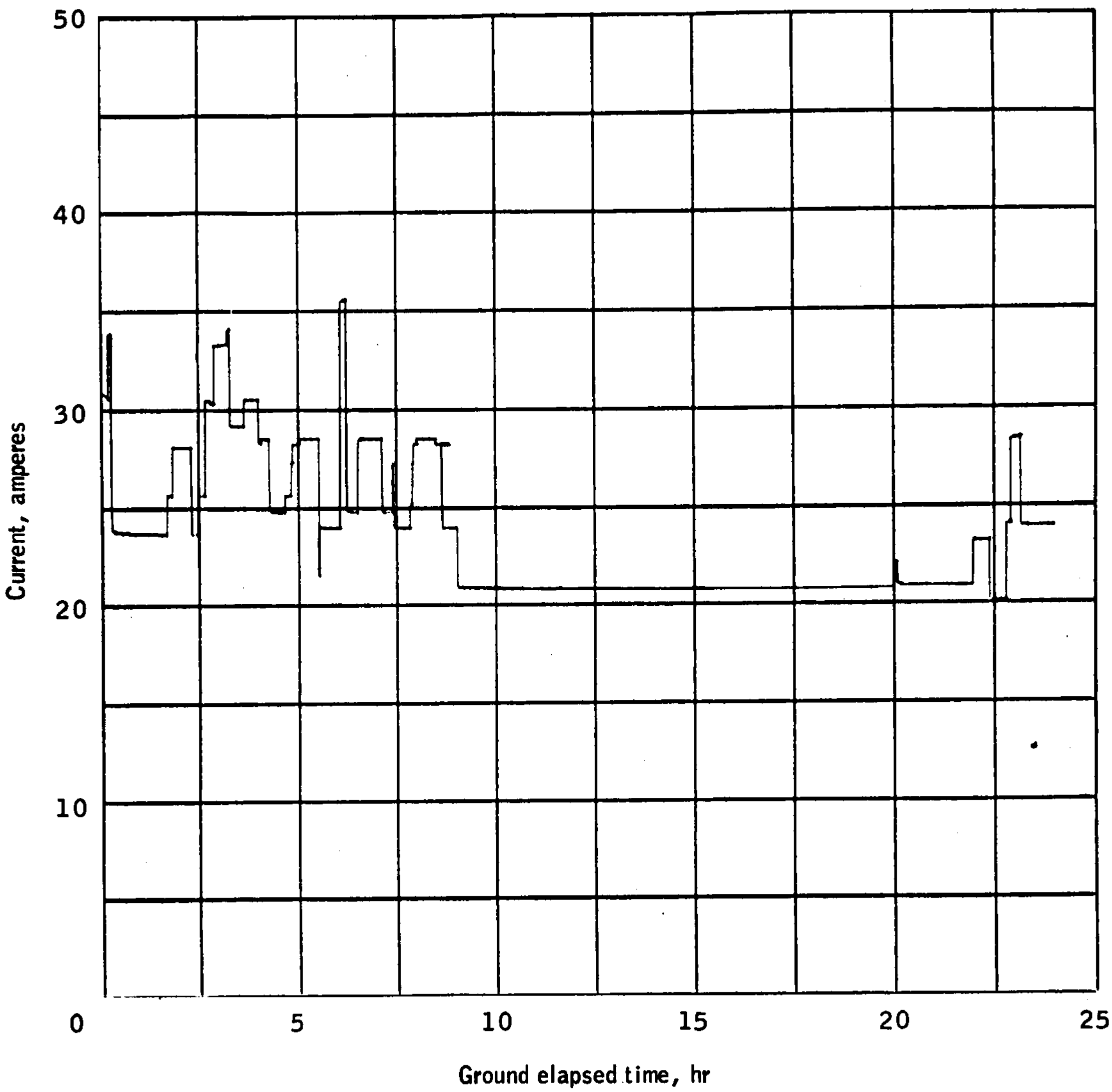
(j) 216 hours to 240 hours, ground elapsed time.

Figure 5.- Continued.



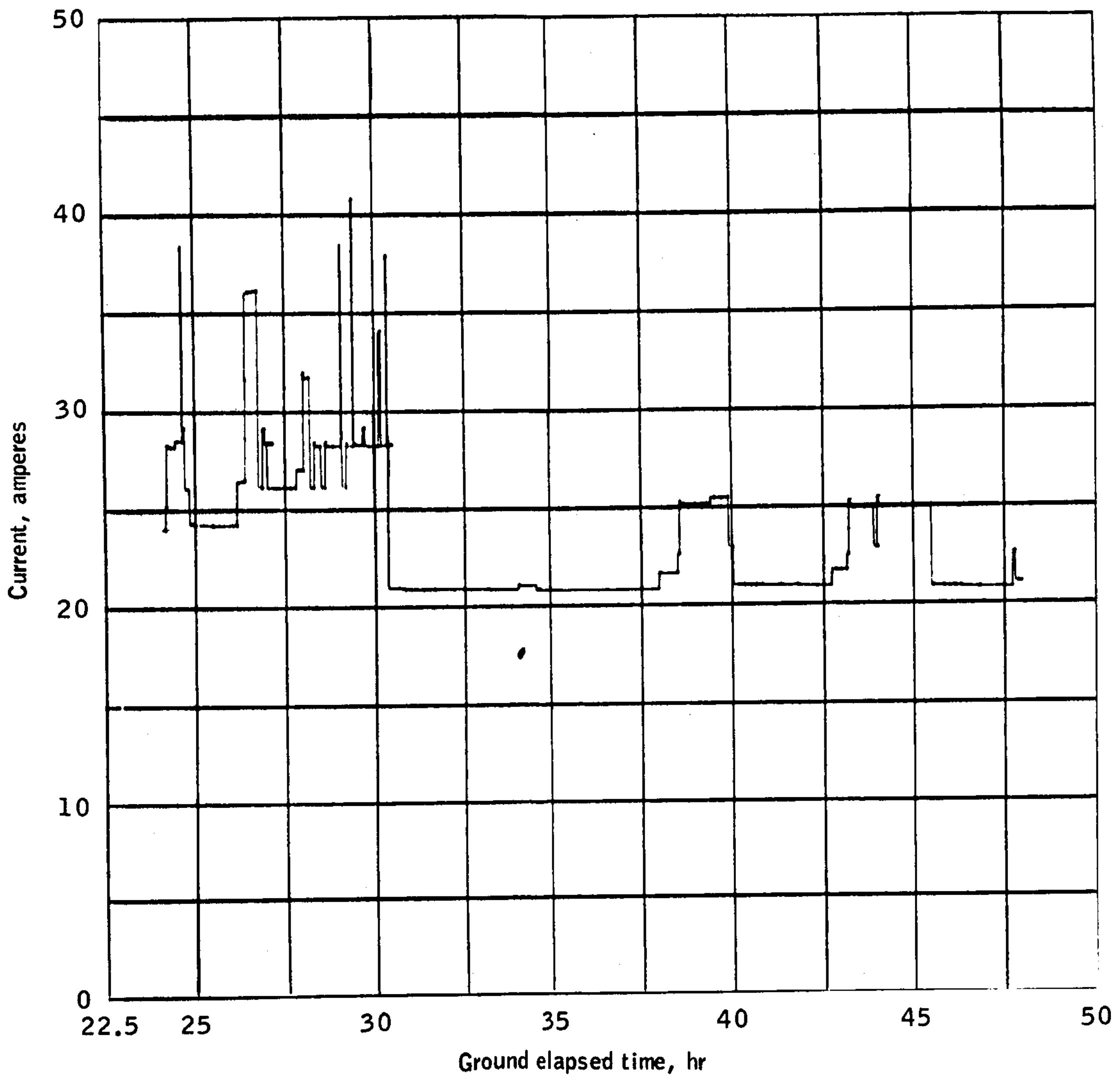
(k) 240 hours to 260 hours, ground elapsed time.

Figure 5.- Concluded.



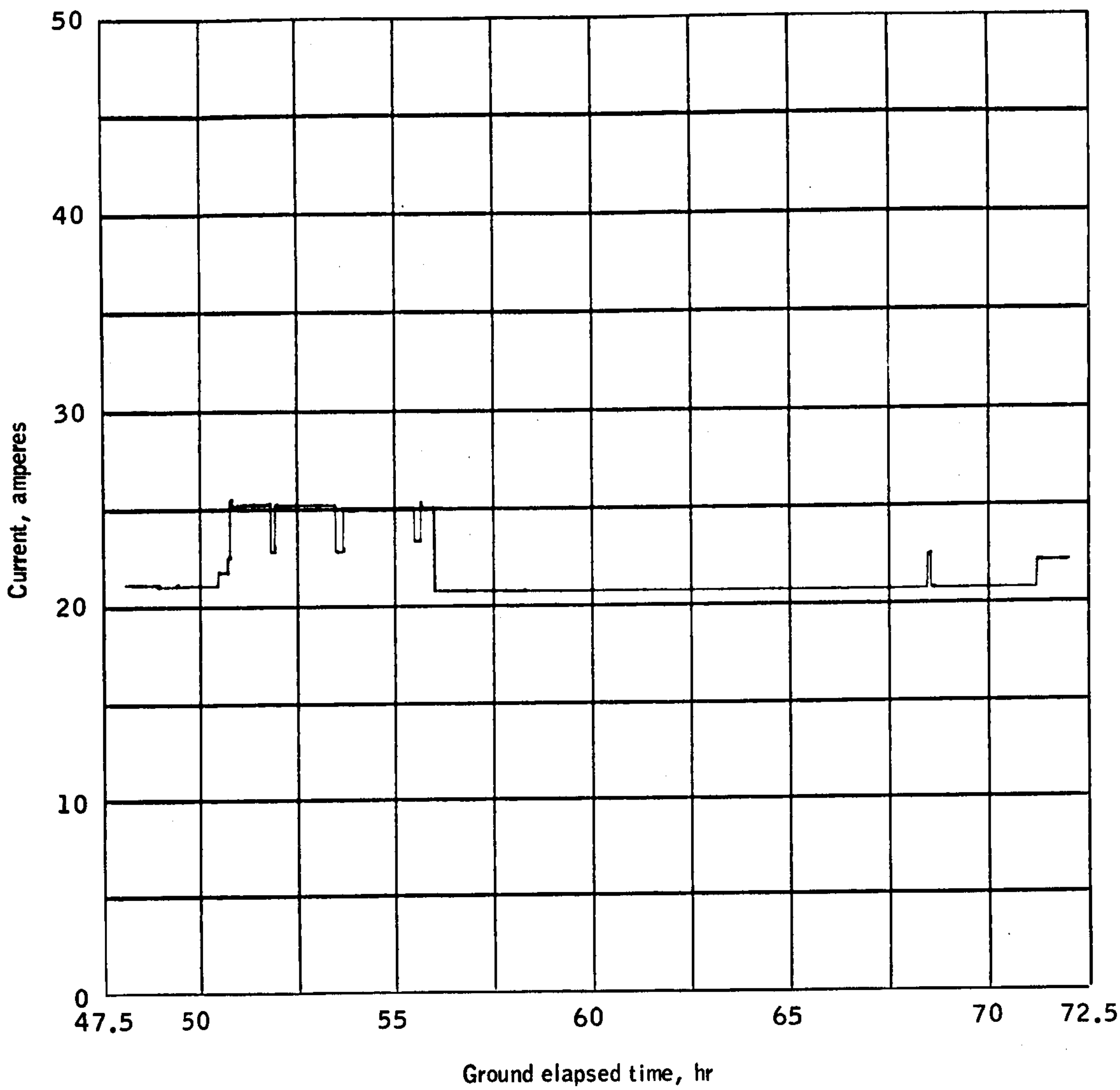
(a) Lift-off to 24 hours, ground elapsed time.

Figure 6.- Time history of fuel cell 2 current.



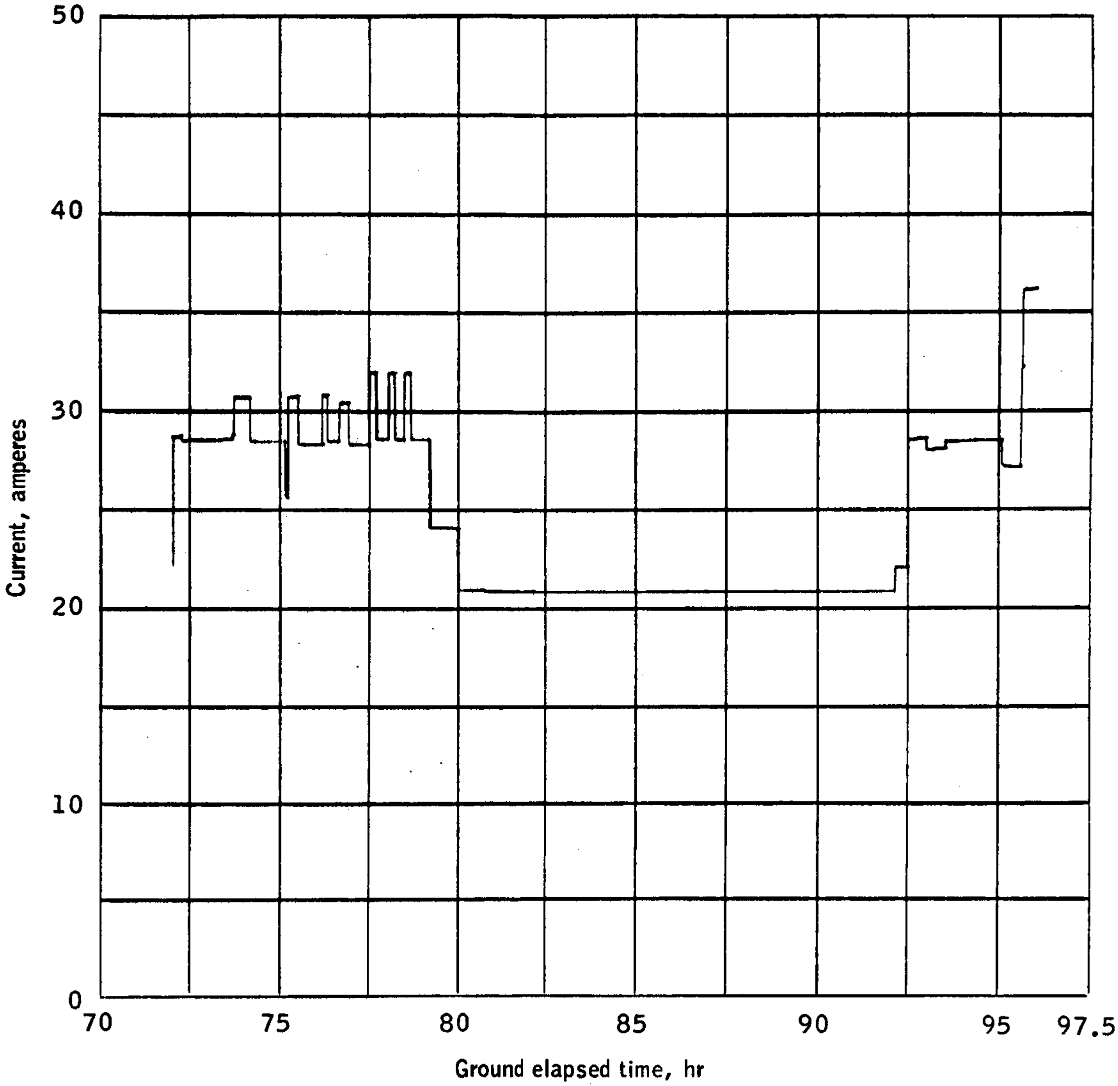
(b) 24 hours to 48 hours, ground elapsed time.

Figure 6.- Continued.



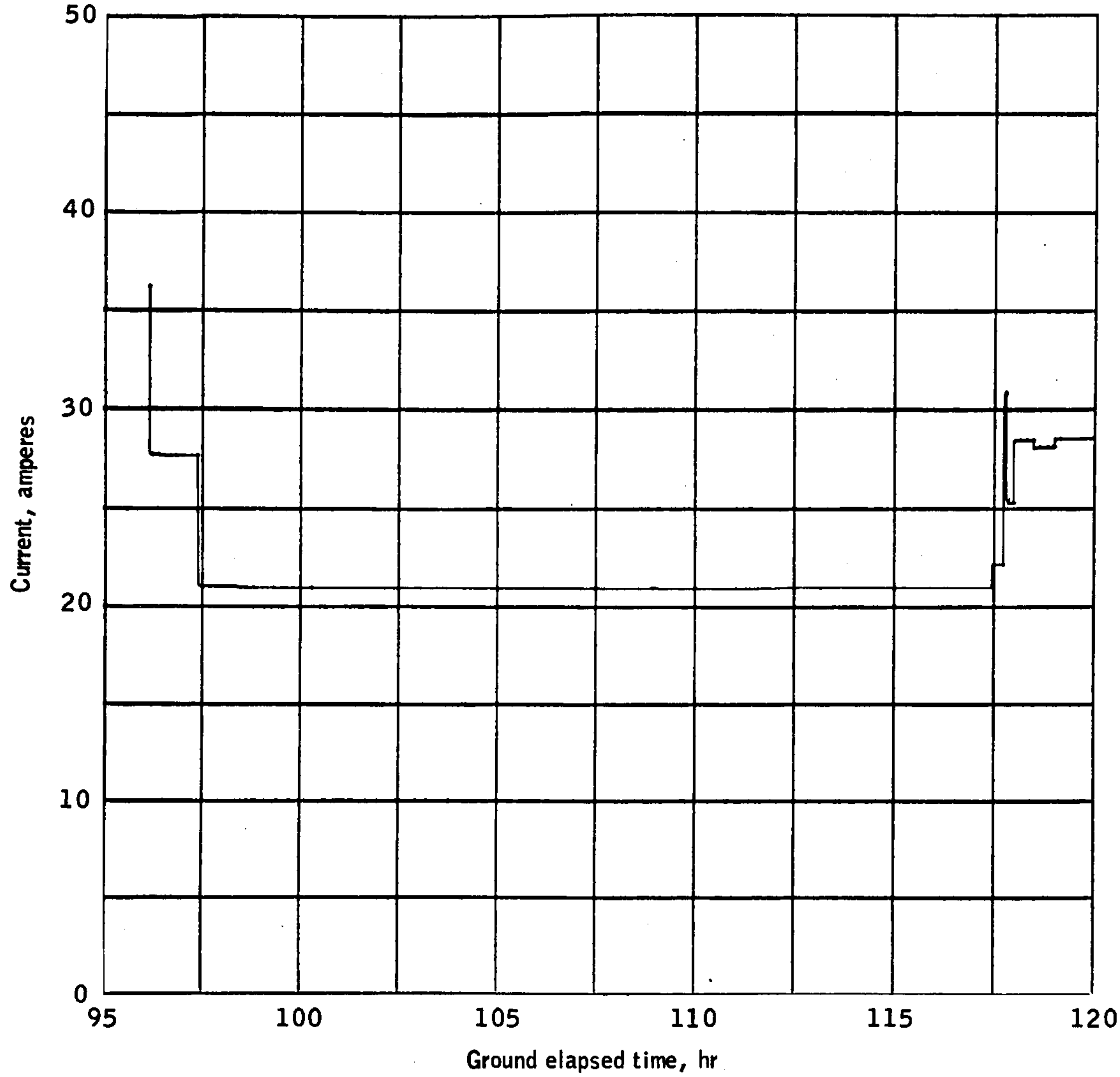
(c) 48 hours to 72 hours, ground elapsed time.

Figure 6.- Continued.



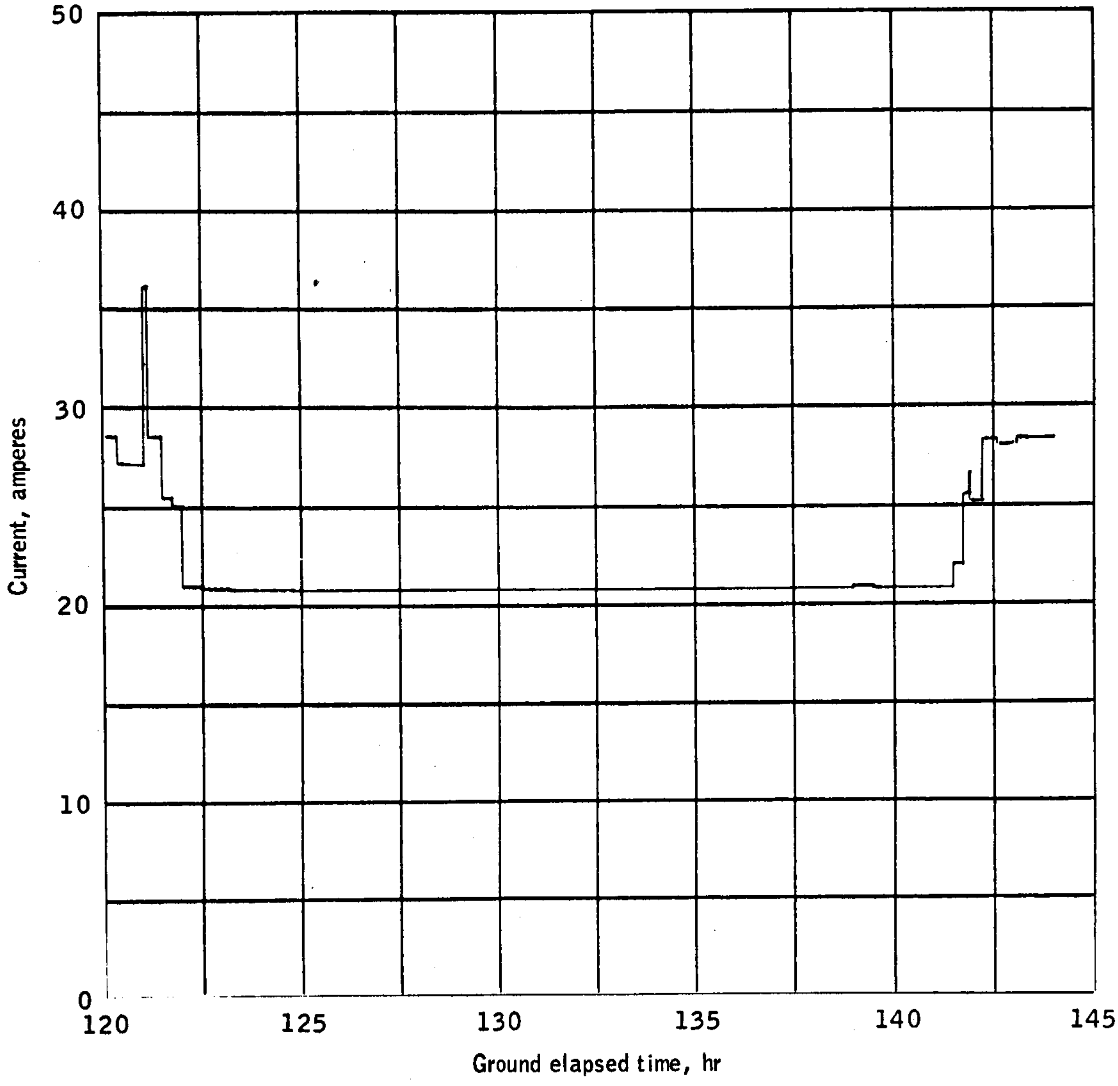
(d) 72 hours to 96 hours, ground elapsed time.

Figure 6.- Continued.



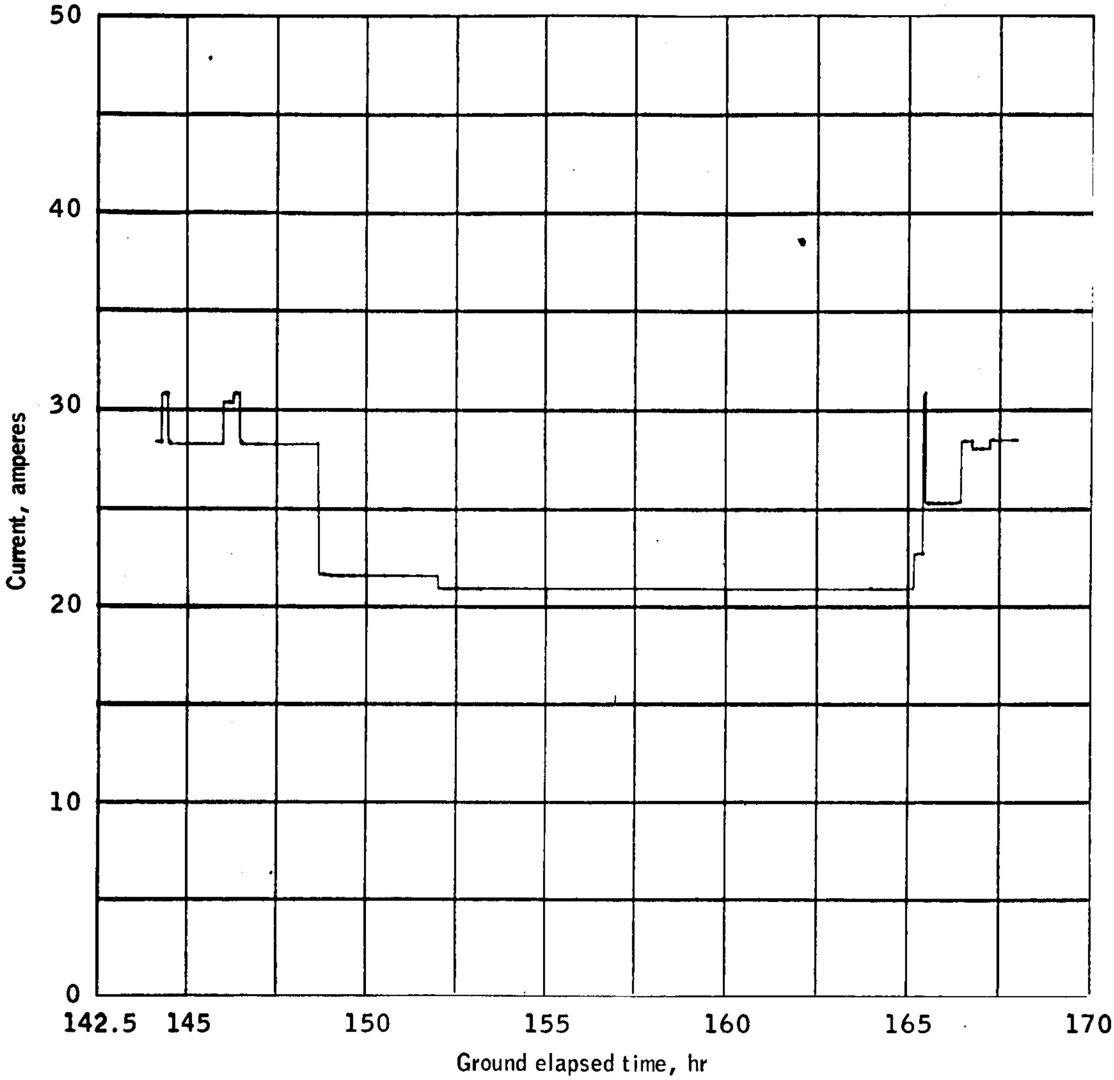
(e) 96 hours to 120 hours, ground elapsed time.

Figure 6.- Continued.



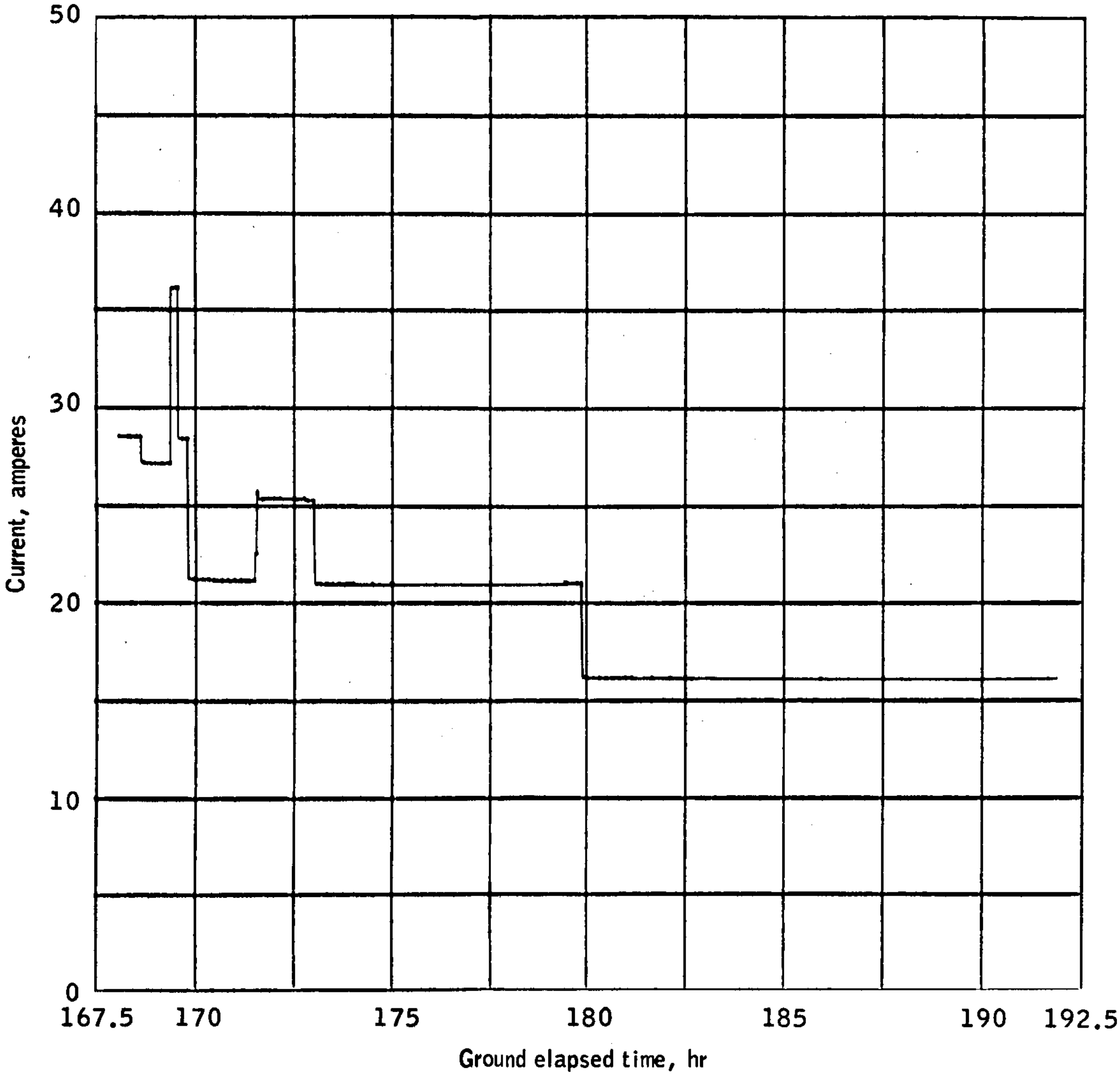
(f) 120 hours to 144 hours, ground elapsed time.

Figure 6.- Continued.



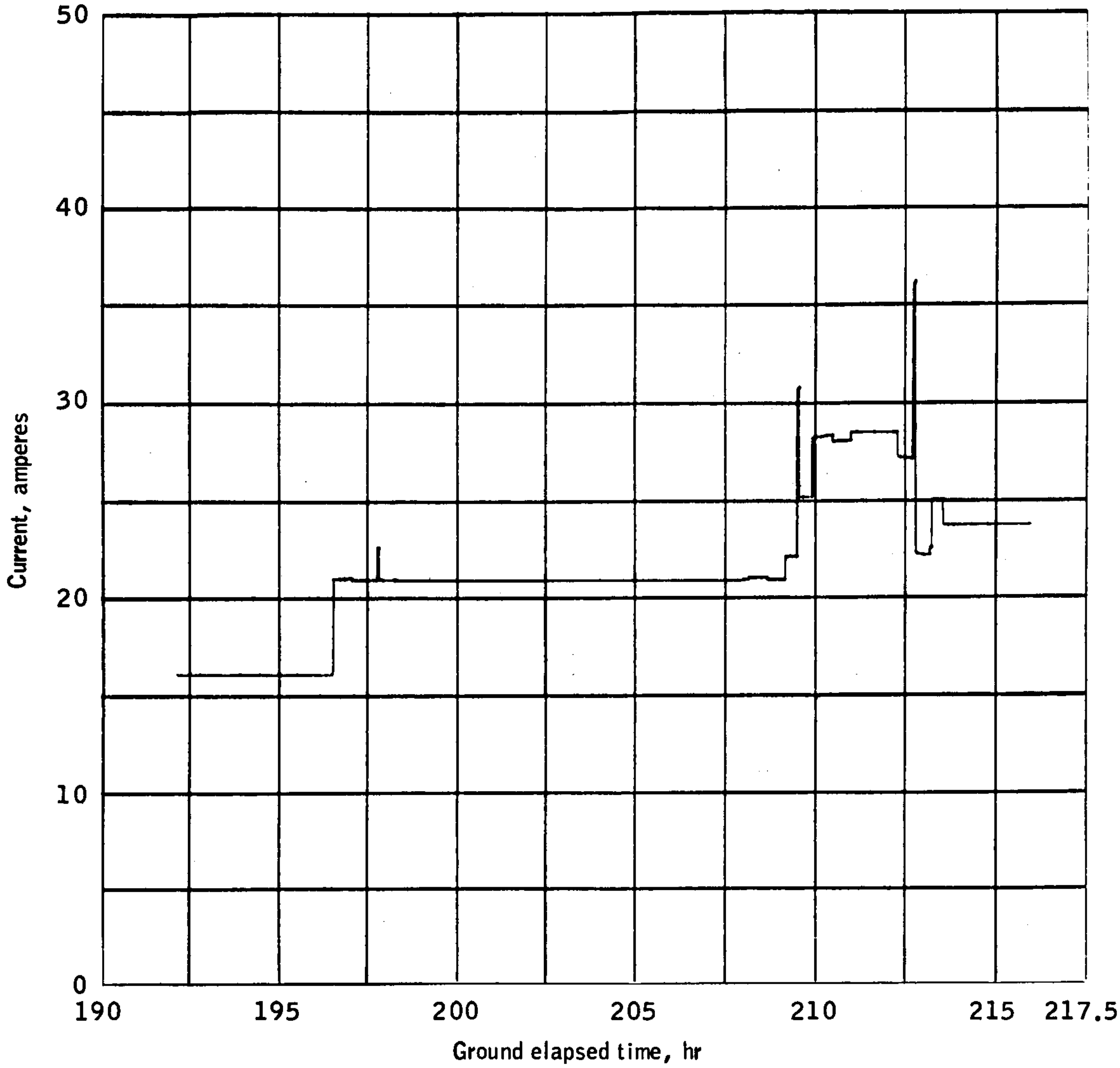
(g) 144 hours to 168 hours, ground elapsed time.

Figure 6.- Continued.



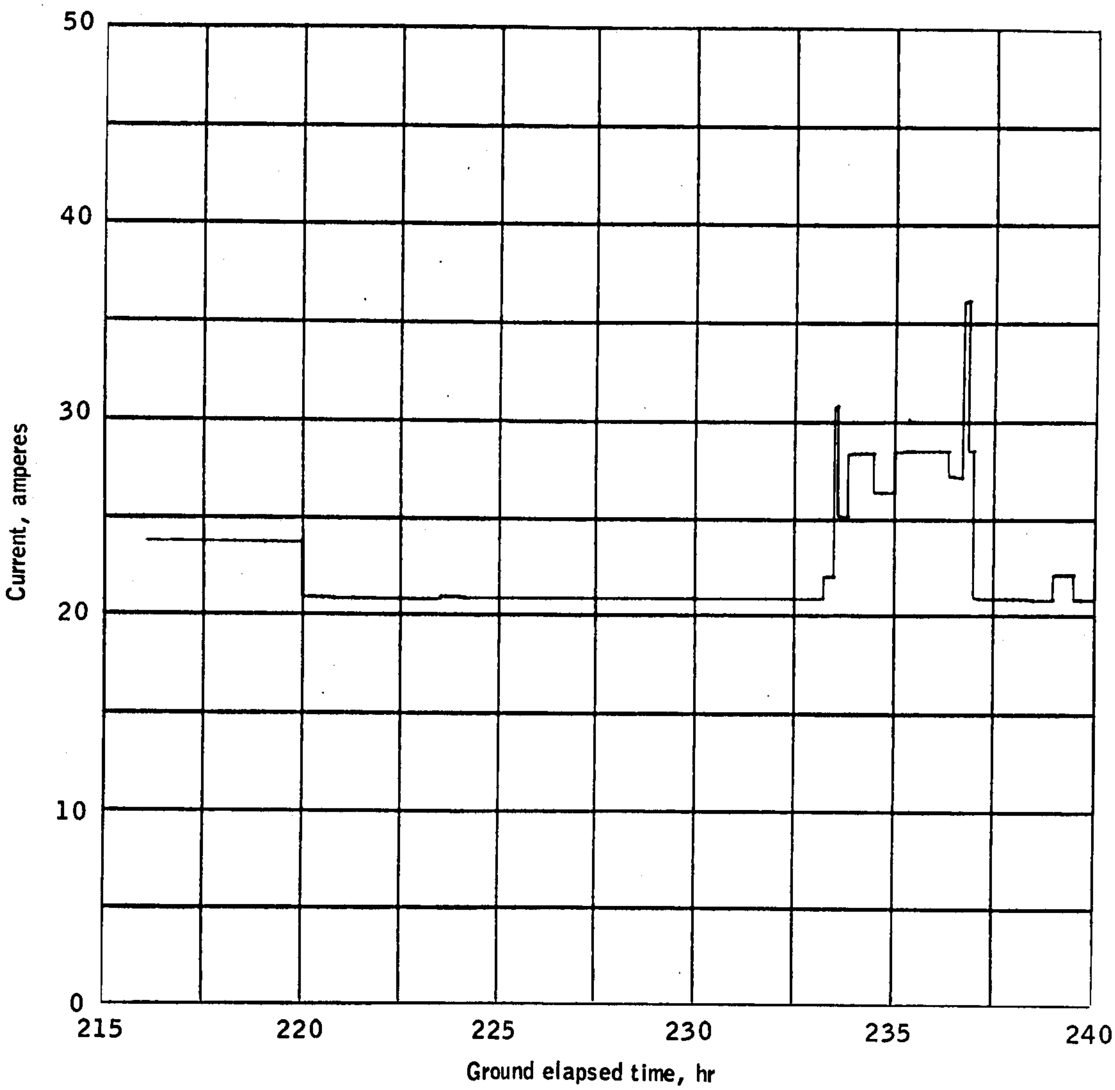
(h) 168 hours to 192 hours, ground elapsed time.

Figure 6.- Continued.



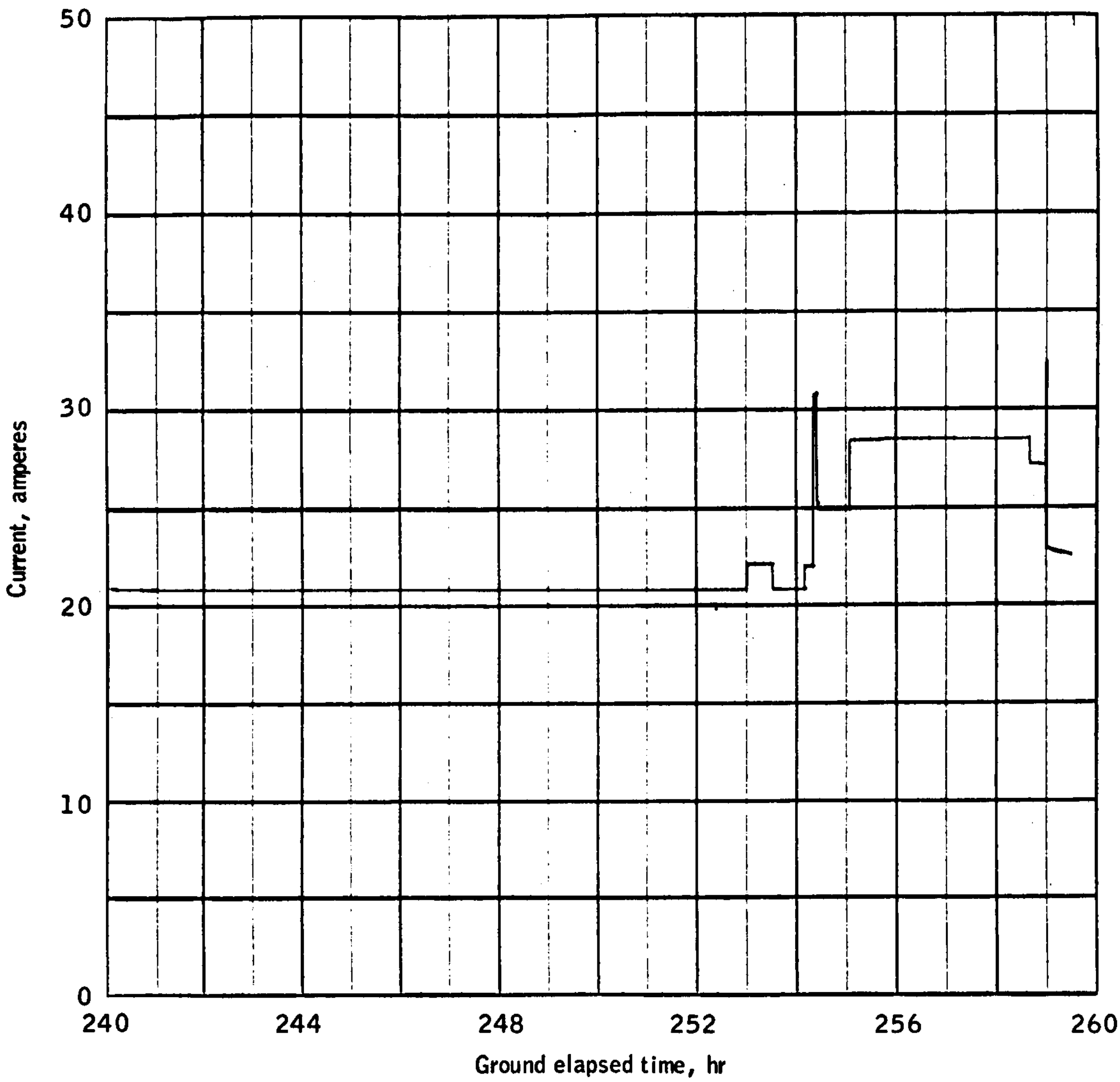
(i) 192 hours to 216 hours, ground elapsed time.

Figure 6.- Continued.



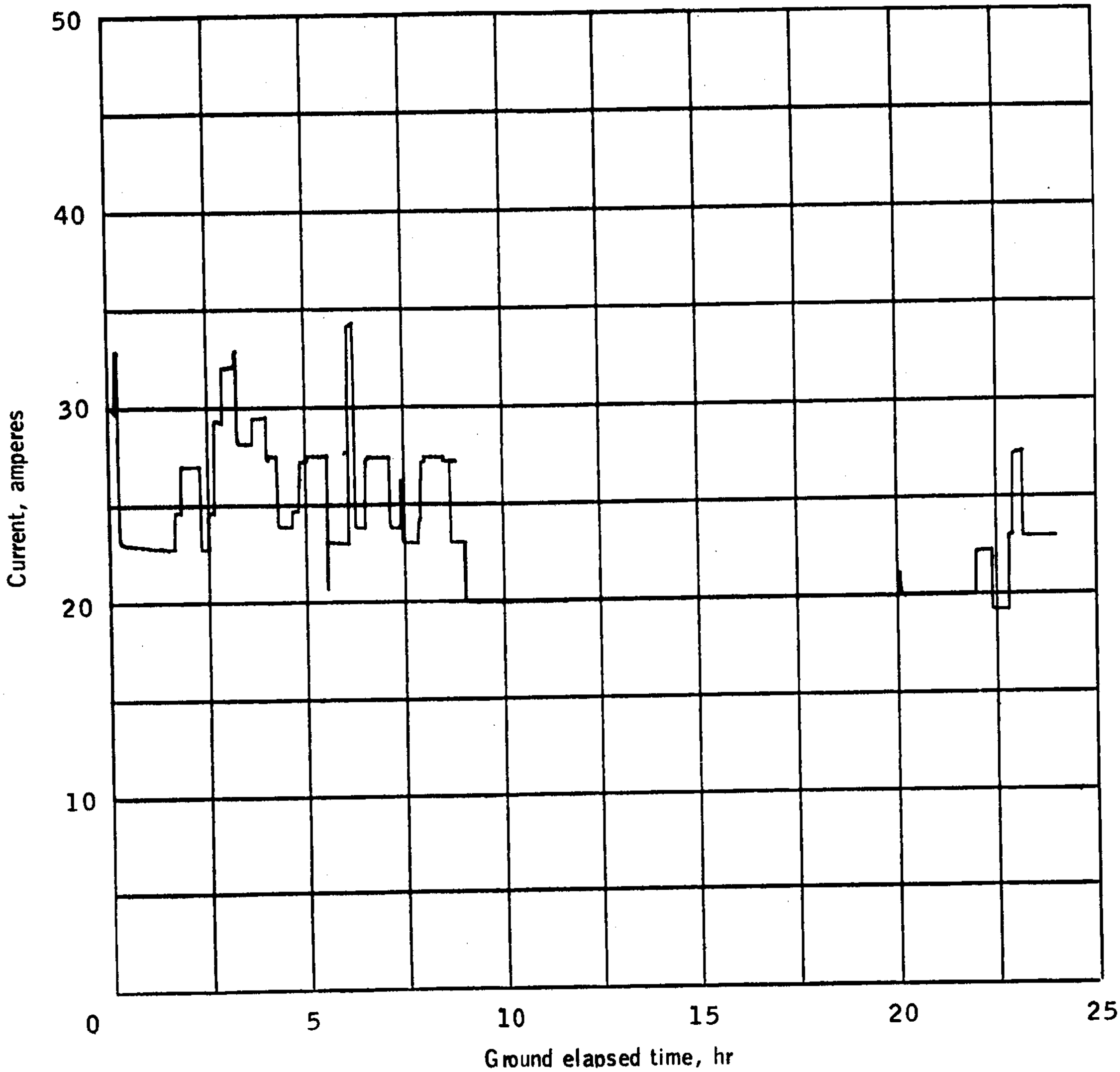
(j) 216 hours to 240 hours, ground elapsed time.

Figure 6.- Continued.



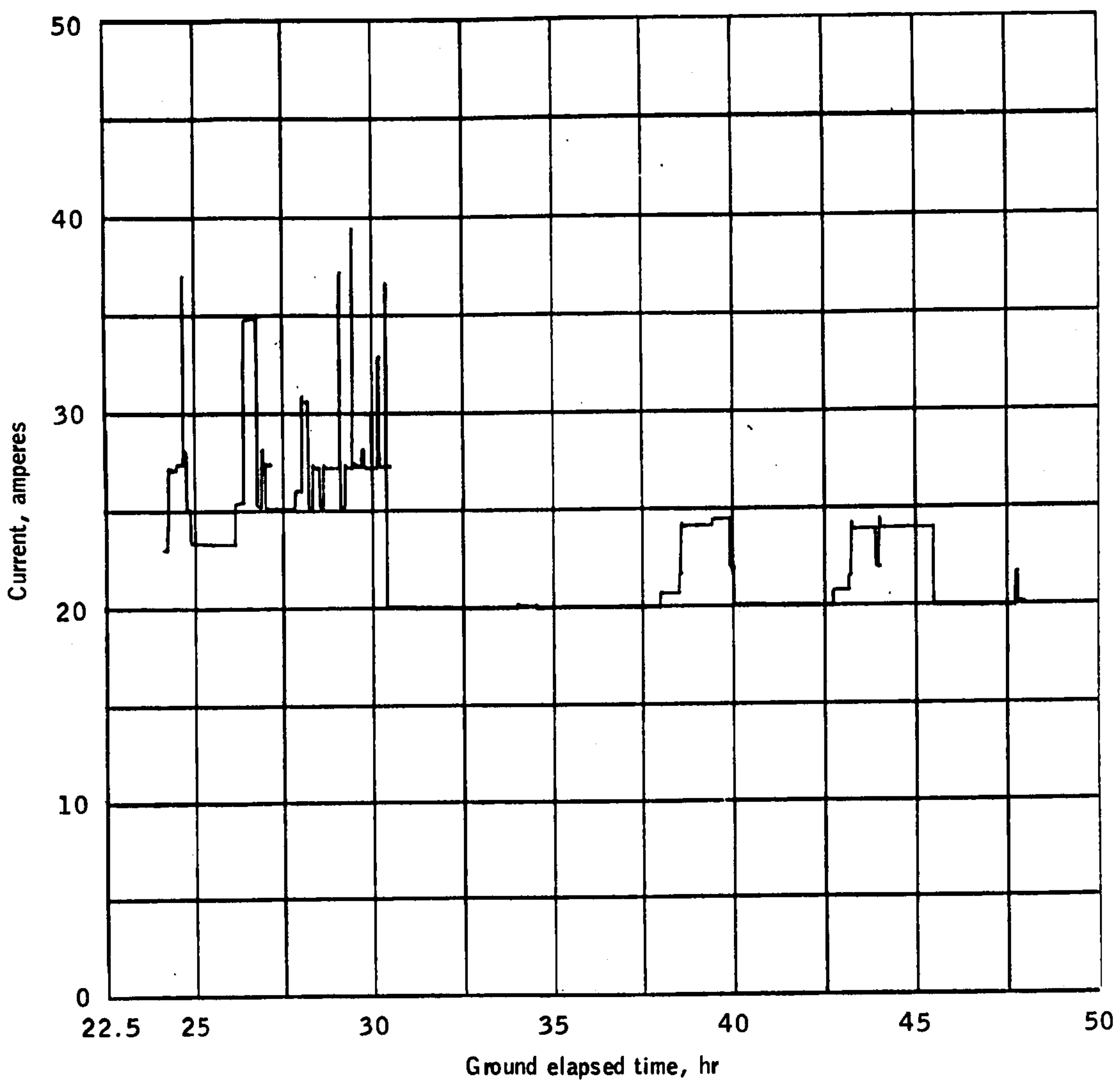
(k) 240 hours to 260 hours, ground elapsed time.

Figure 6.- Concluded.



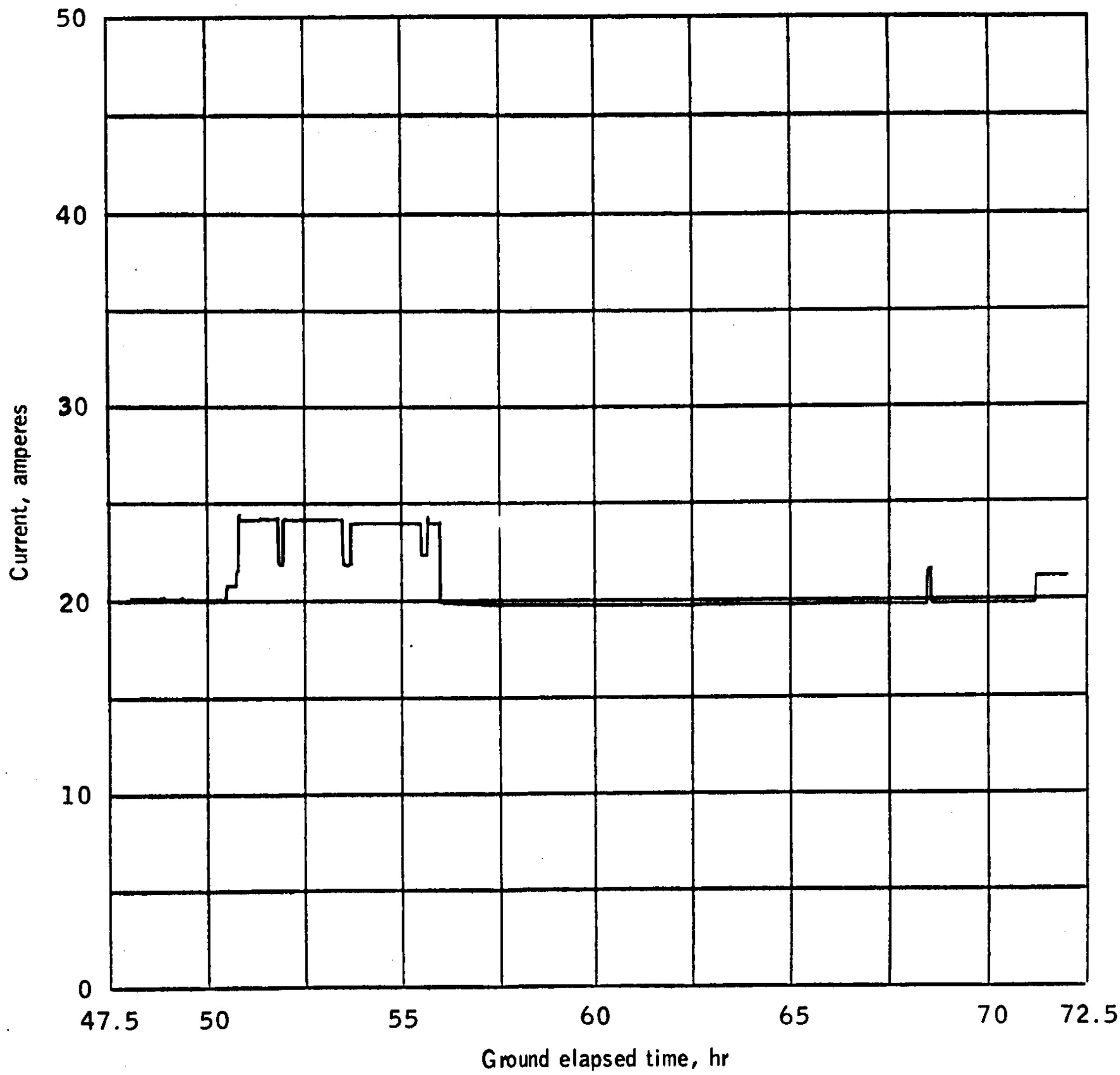
(a) Lift-off to 24 hours, ground elapsed time.

Figure 7.- Time history of fuel cell 3 current.



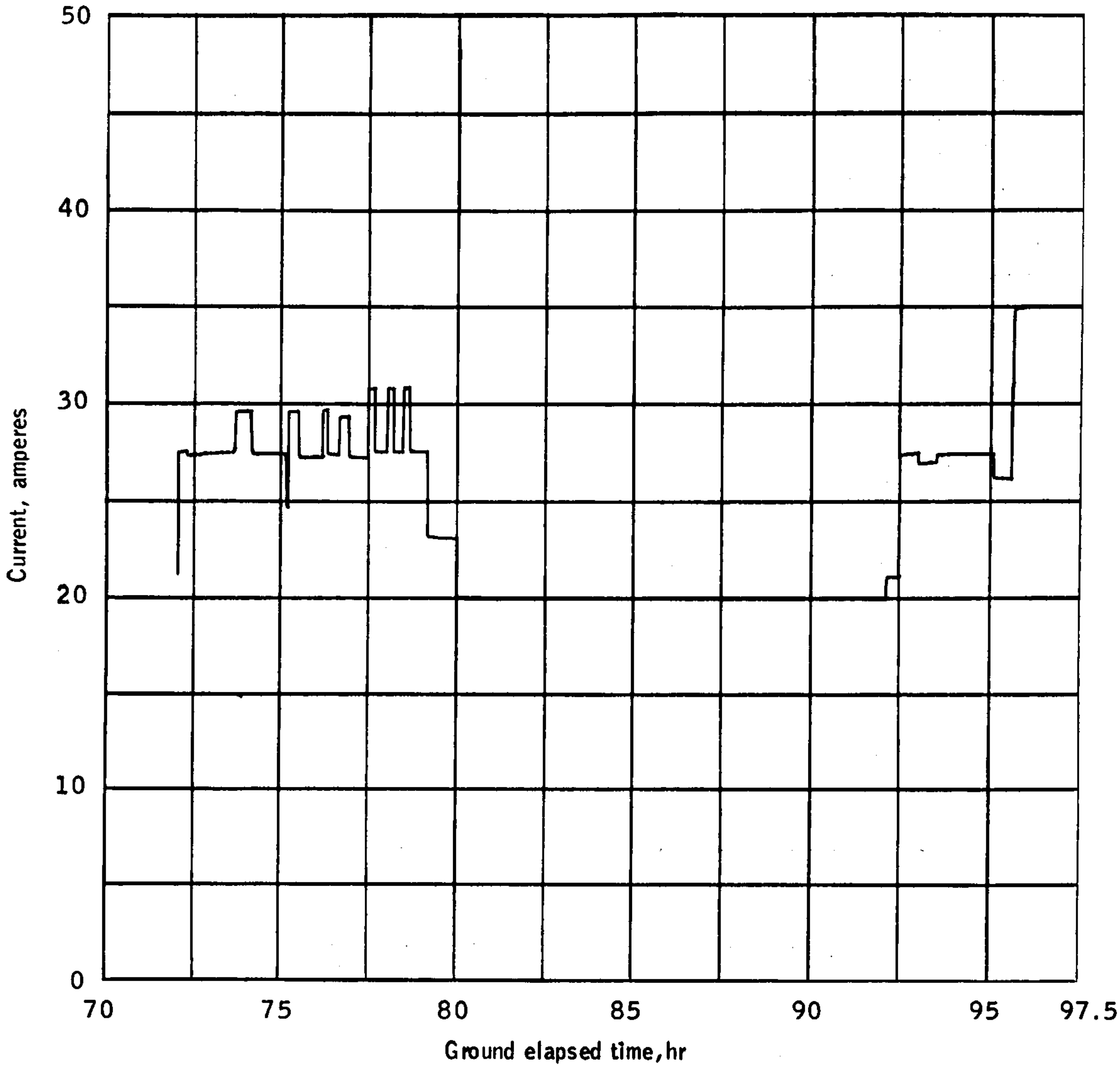
(b) 24 hours to 48 hours, ground elapsed time.

Figure 7.- Continued.



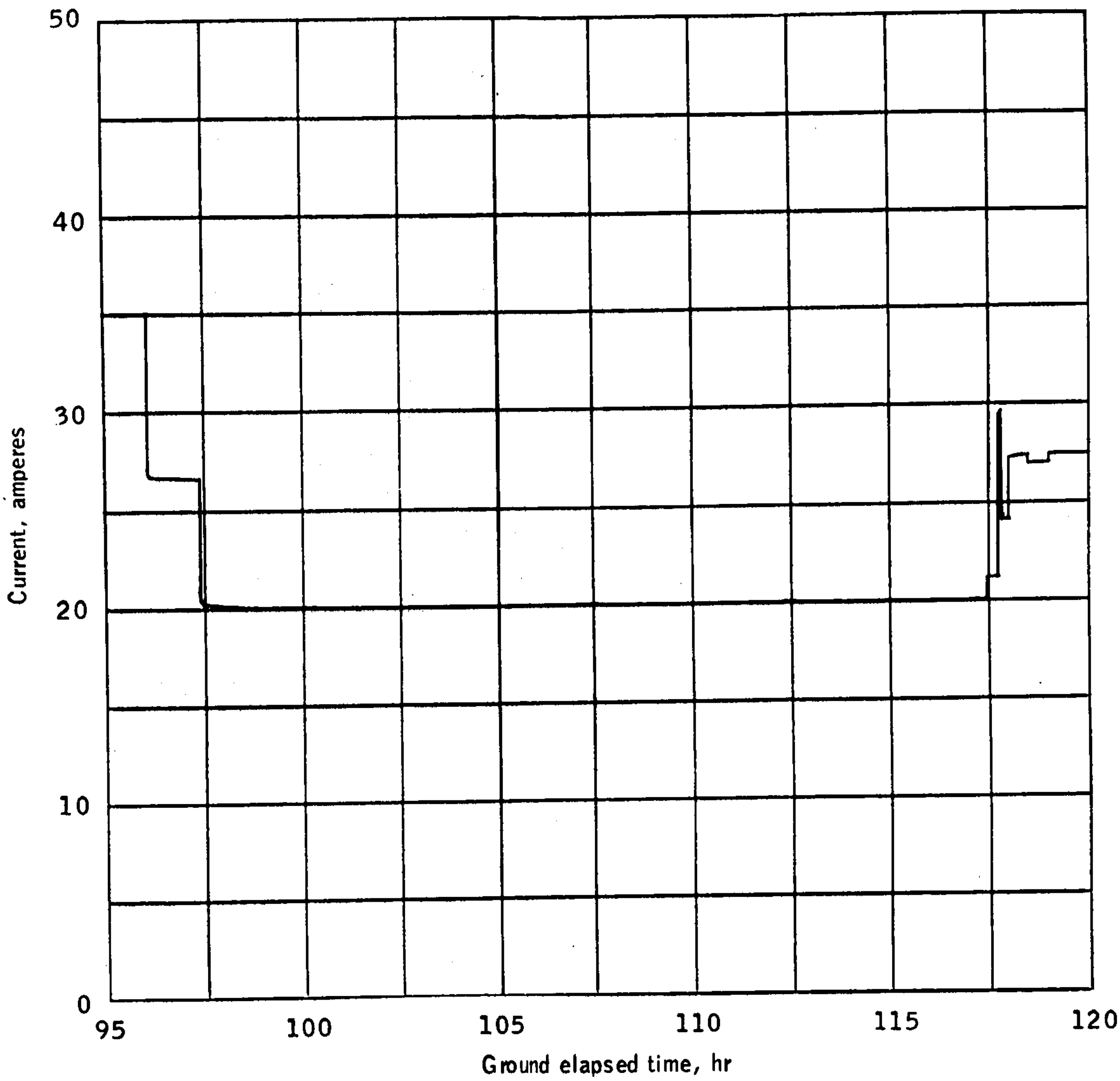
(c) 48 hours to 72 hours, ground elapsed time.

Figure 7. - Continued.



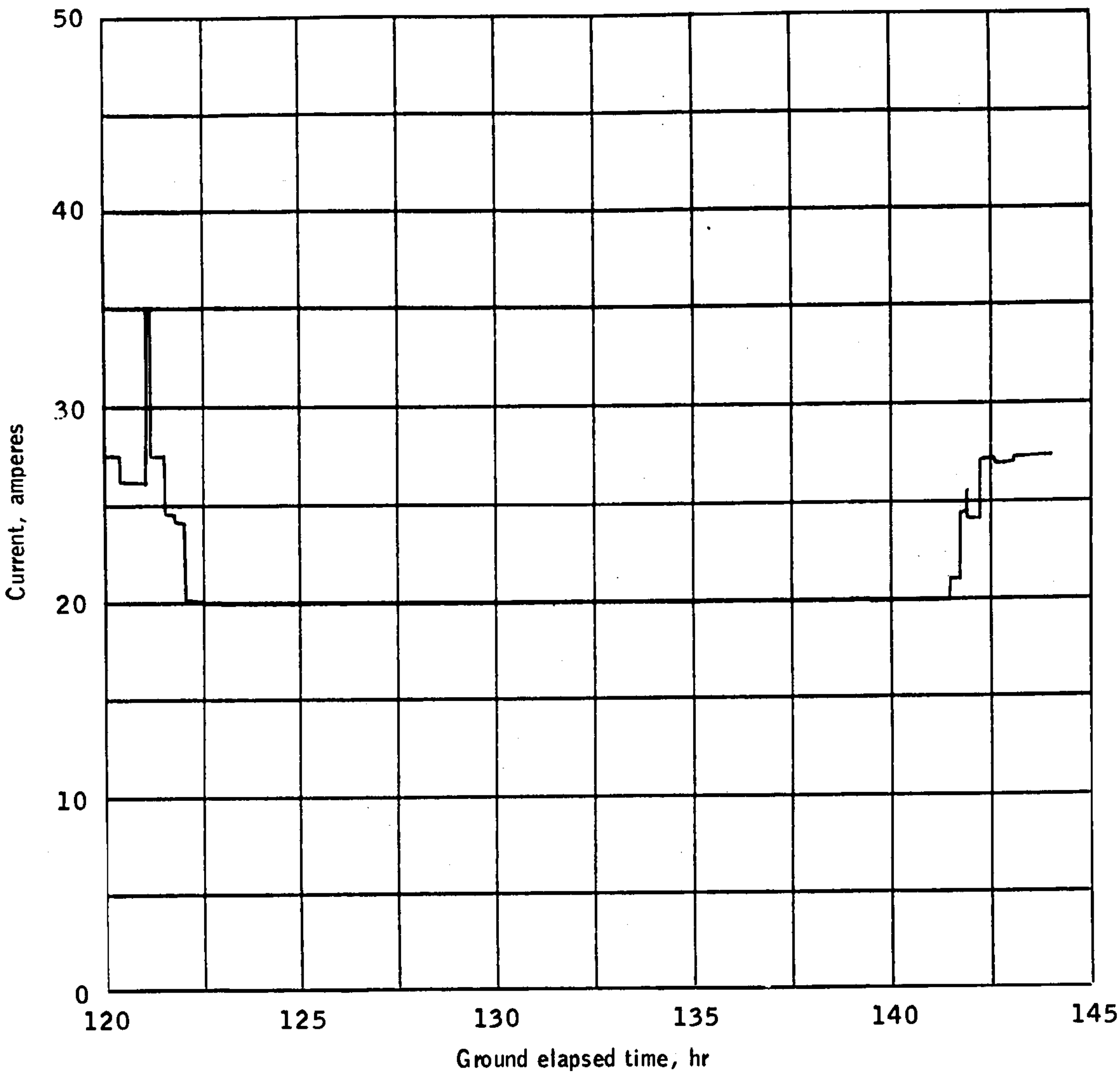
(d) 72 hours to 96 hours, ground elapsed time.

Figure 7.- Continued.



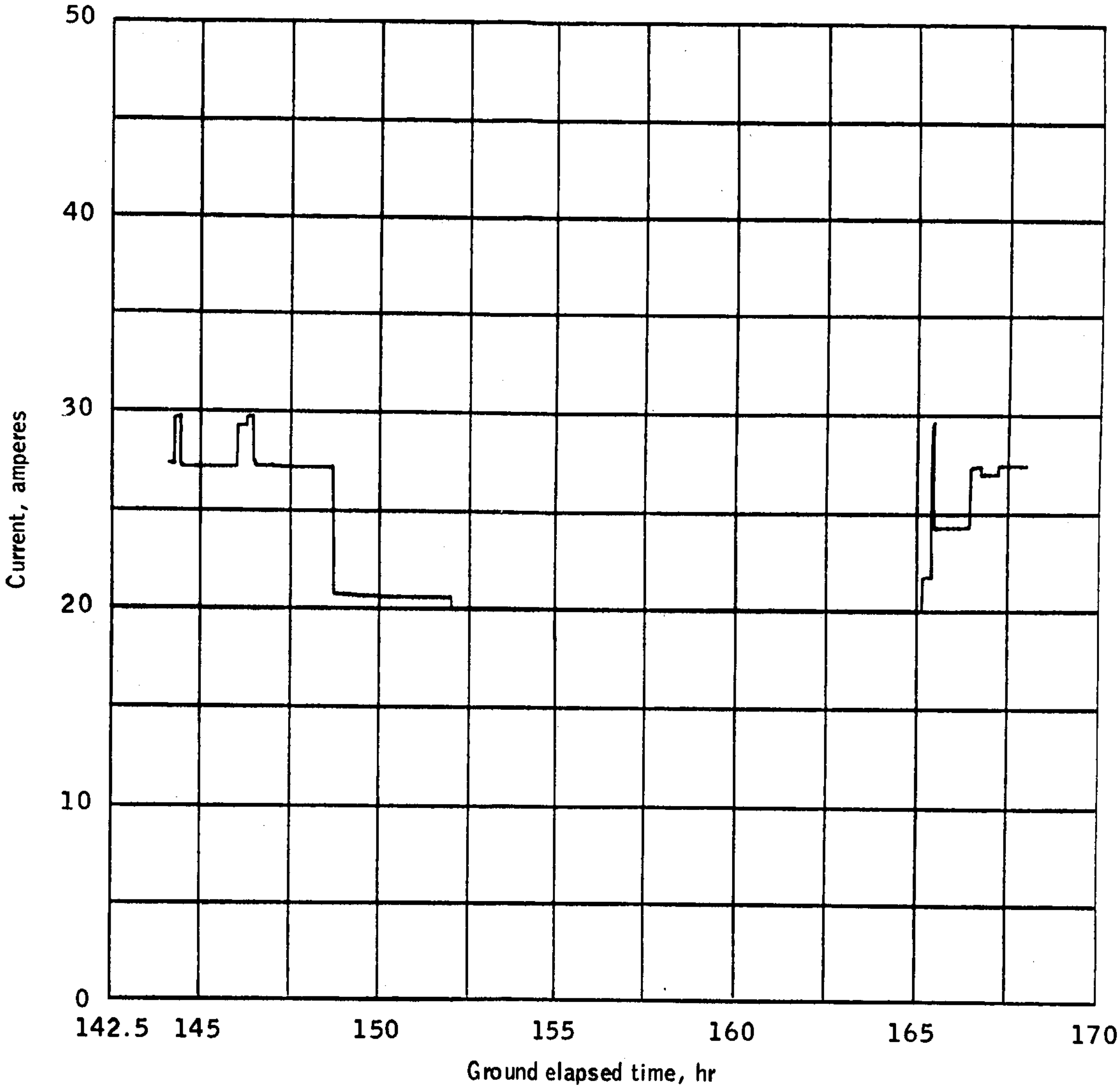
(e) 96 hours to 120 hours, ground elapsed time.

Figure 7. - Continued.



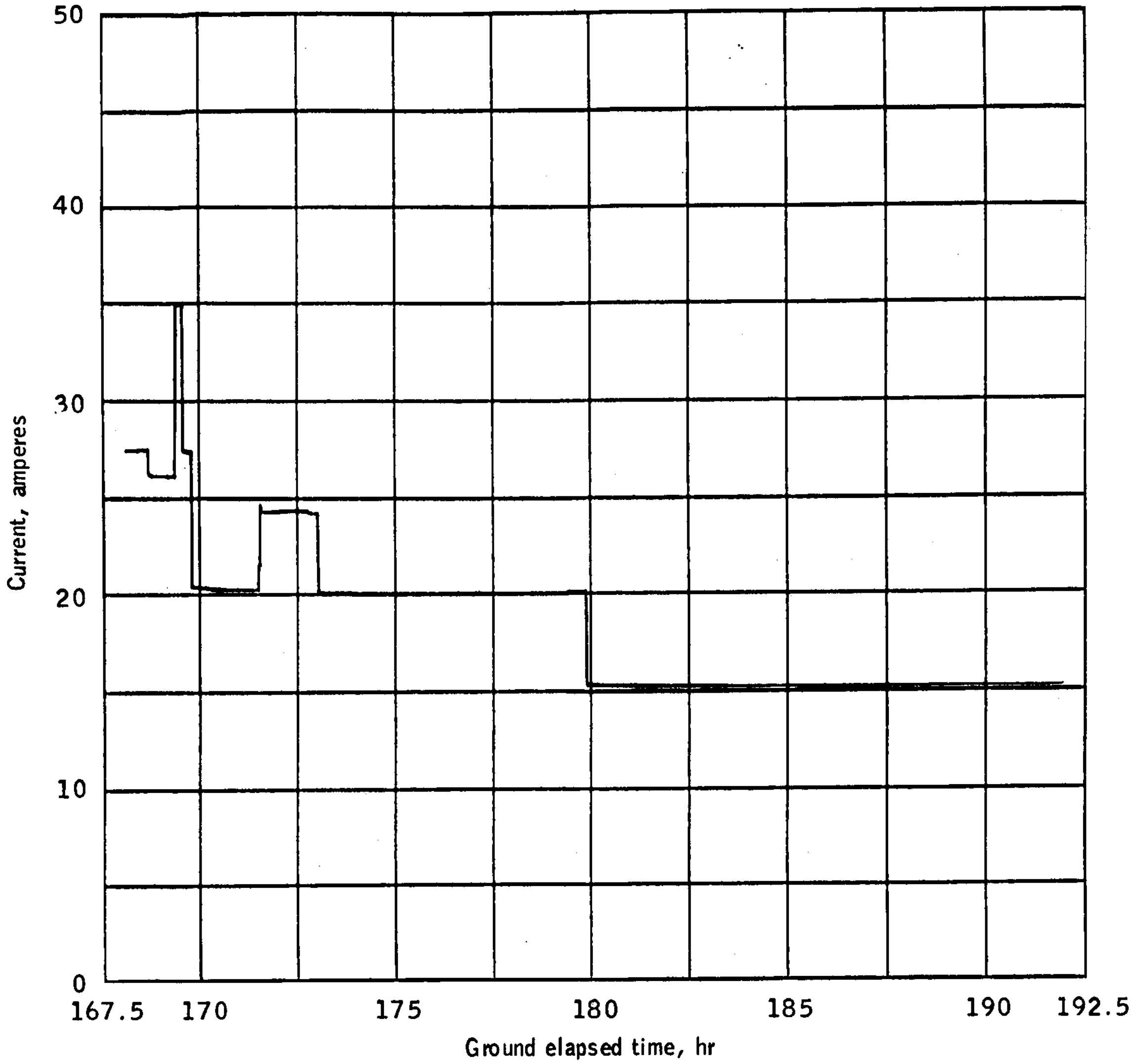
(f) 120 hours to 144 hours, ground elapsed time.

Figure 7. - Continued.



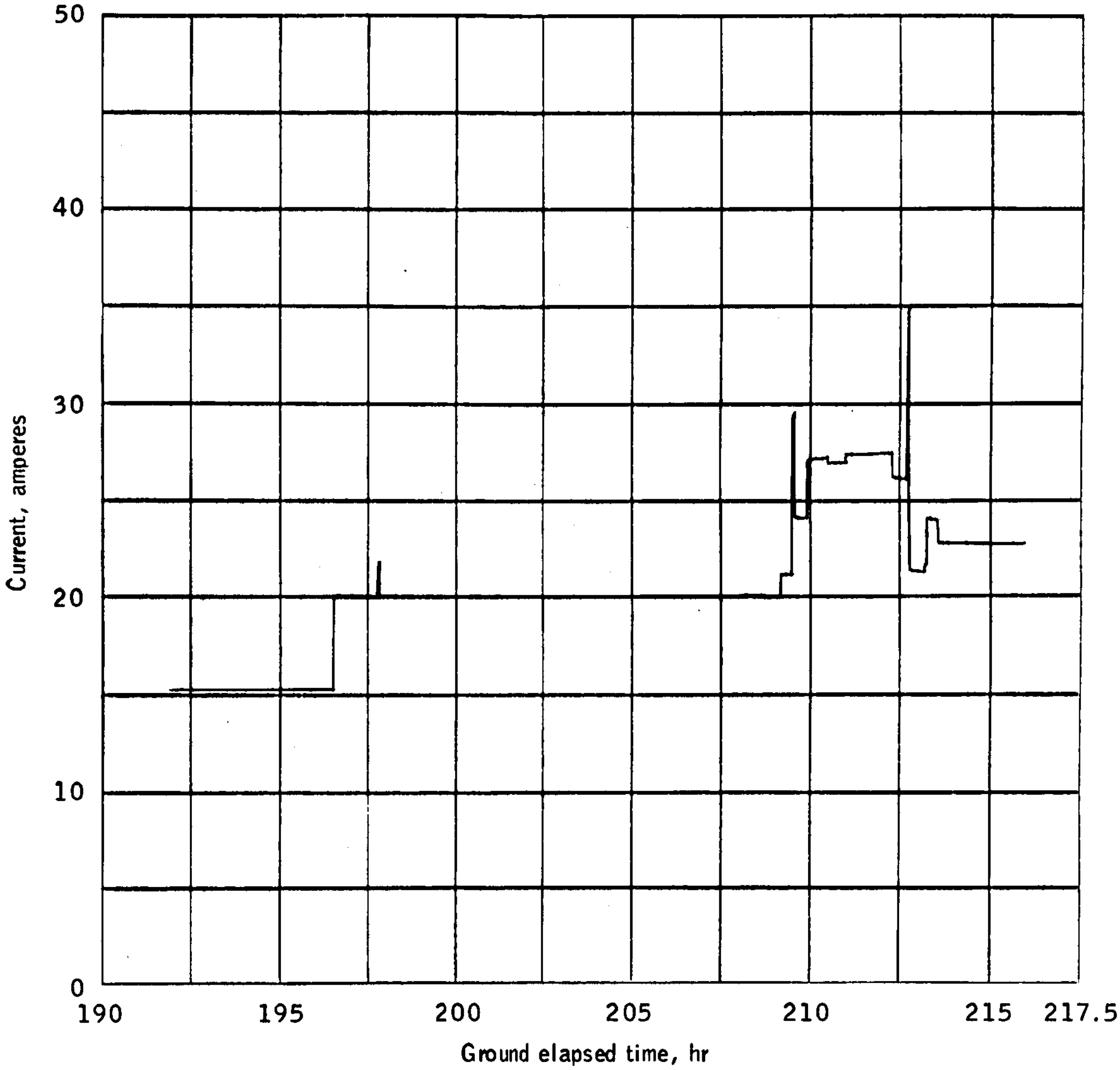
(g) 144 hours to 168 hours, ground elapsed time.

Figure 7.- Continued.



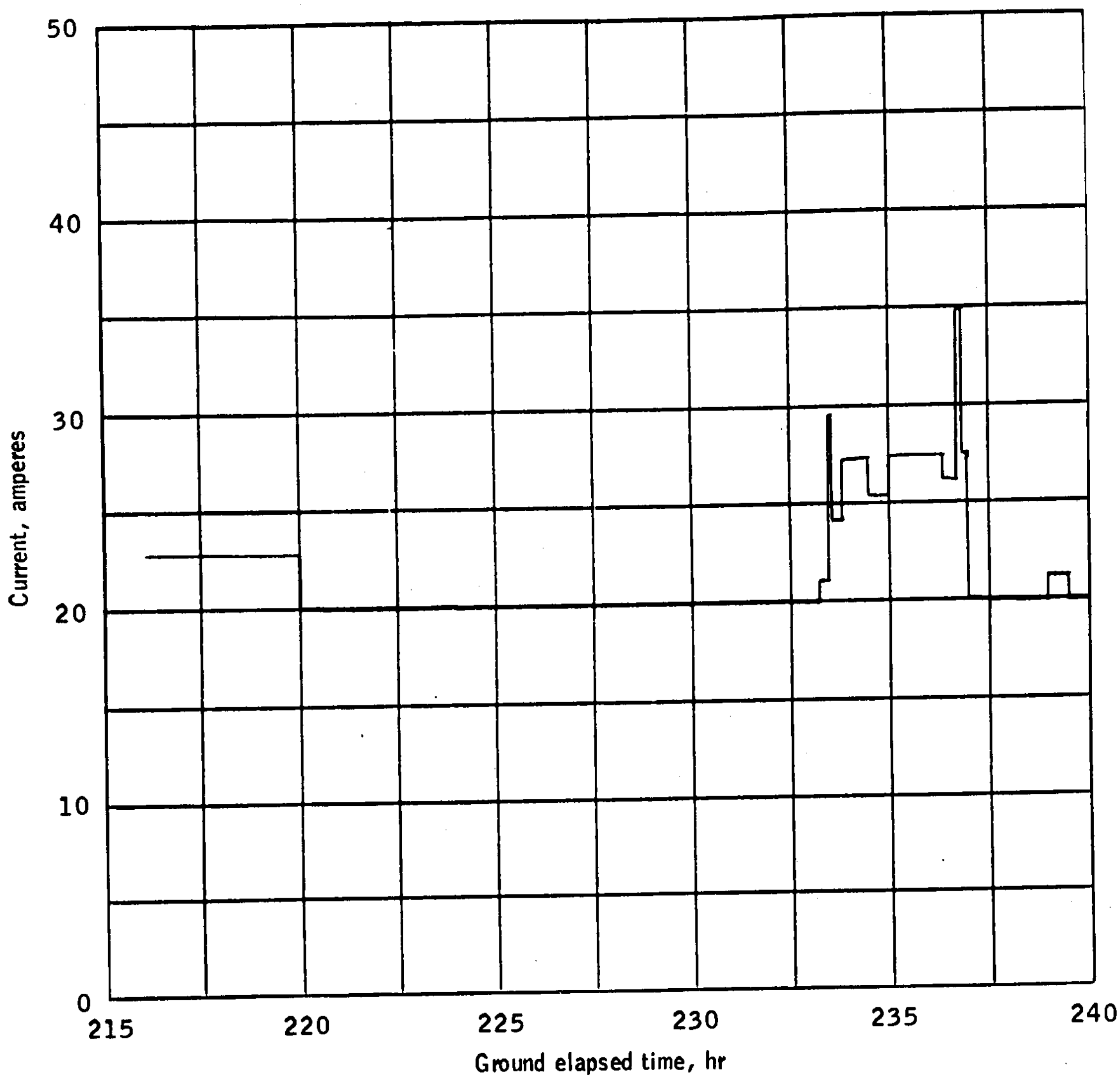
(h) 168 hours to 192 hours, ground elapsed time.

Figure 7.- Continued.



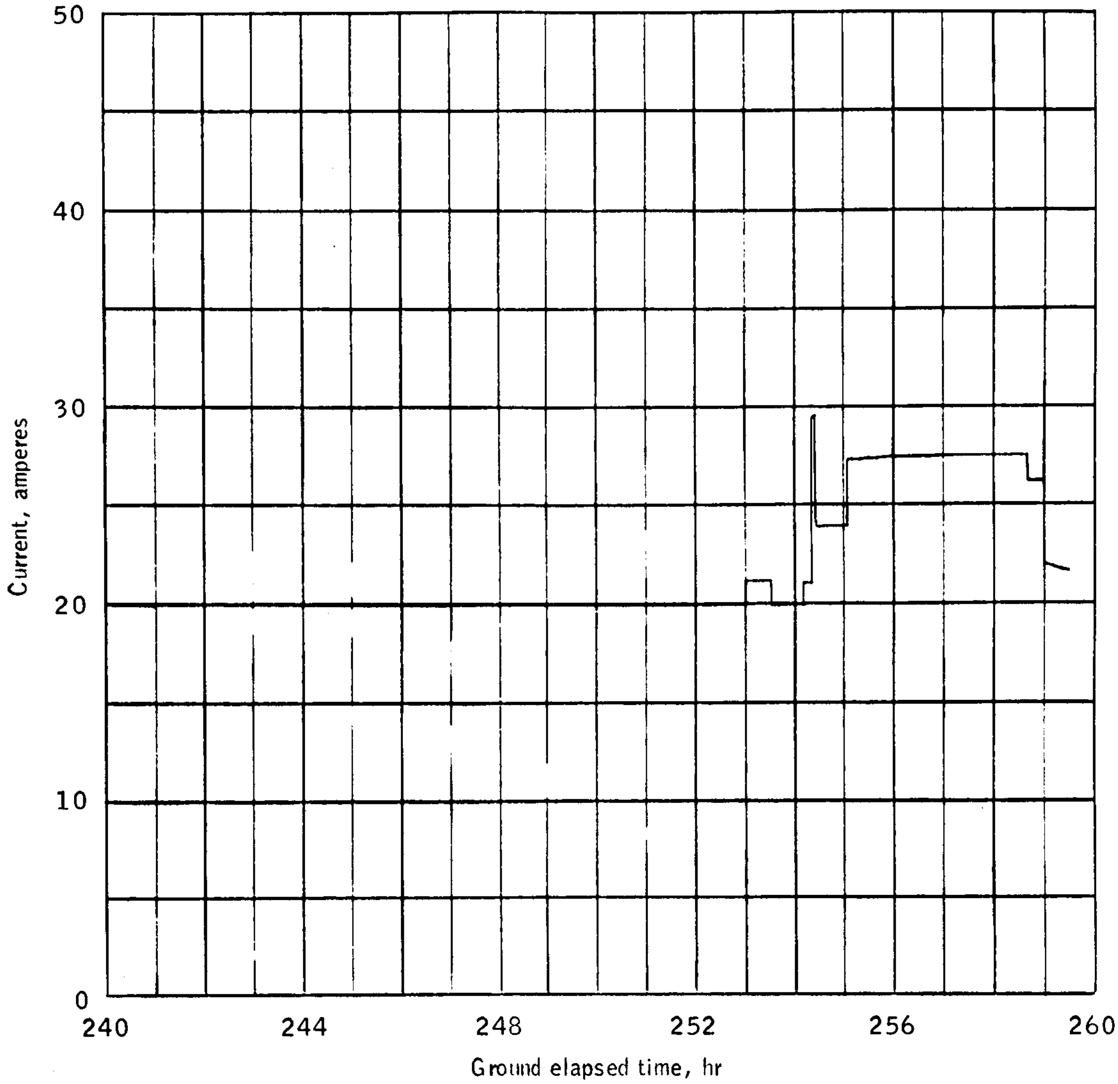
(i) 192 hours to 216 hours, ground elapsed time.

Figure 7.- Continued .



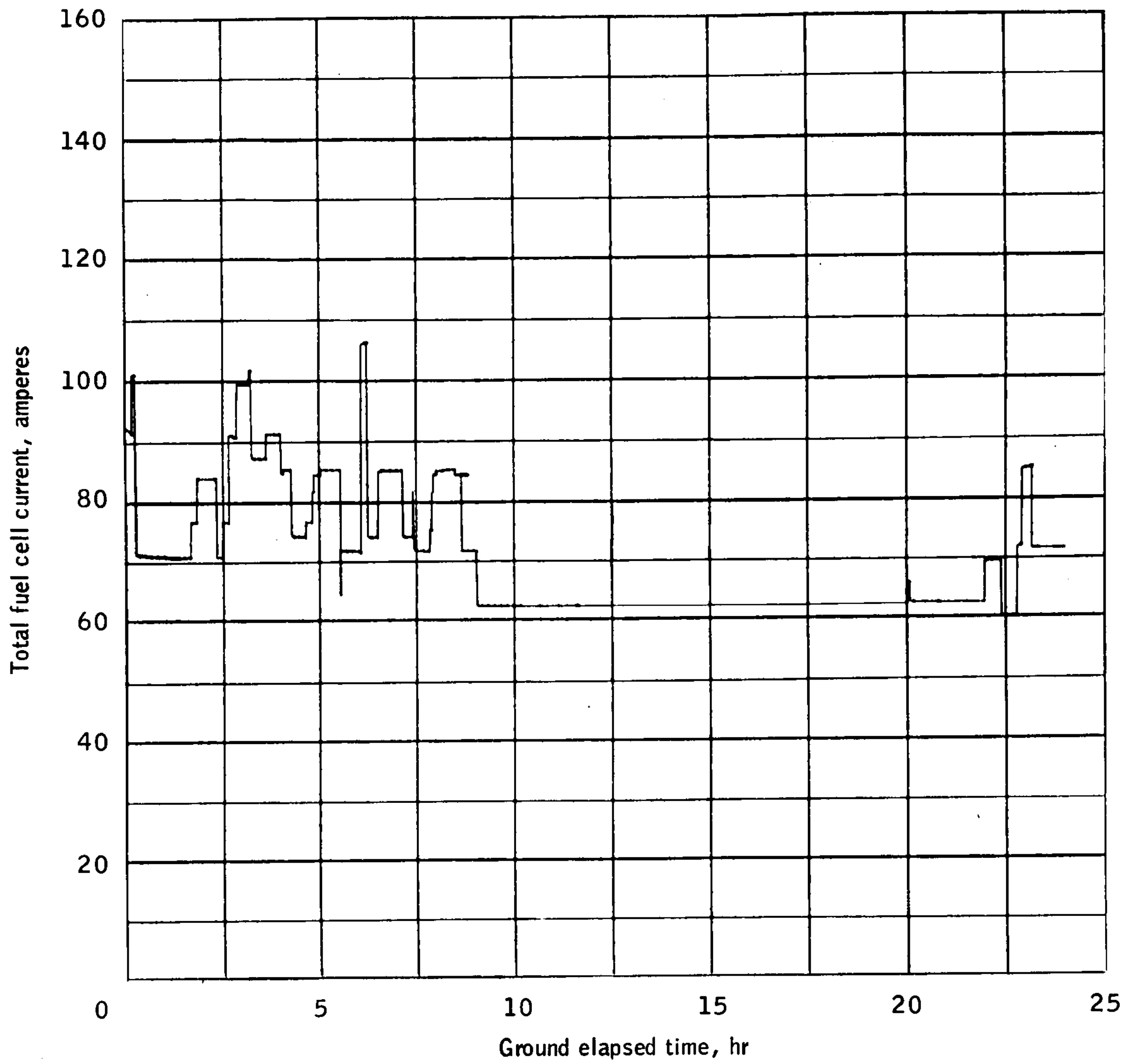
(j) 216 hours to 240 hours, ground elapsed time.

Figure 7.- Continued.



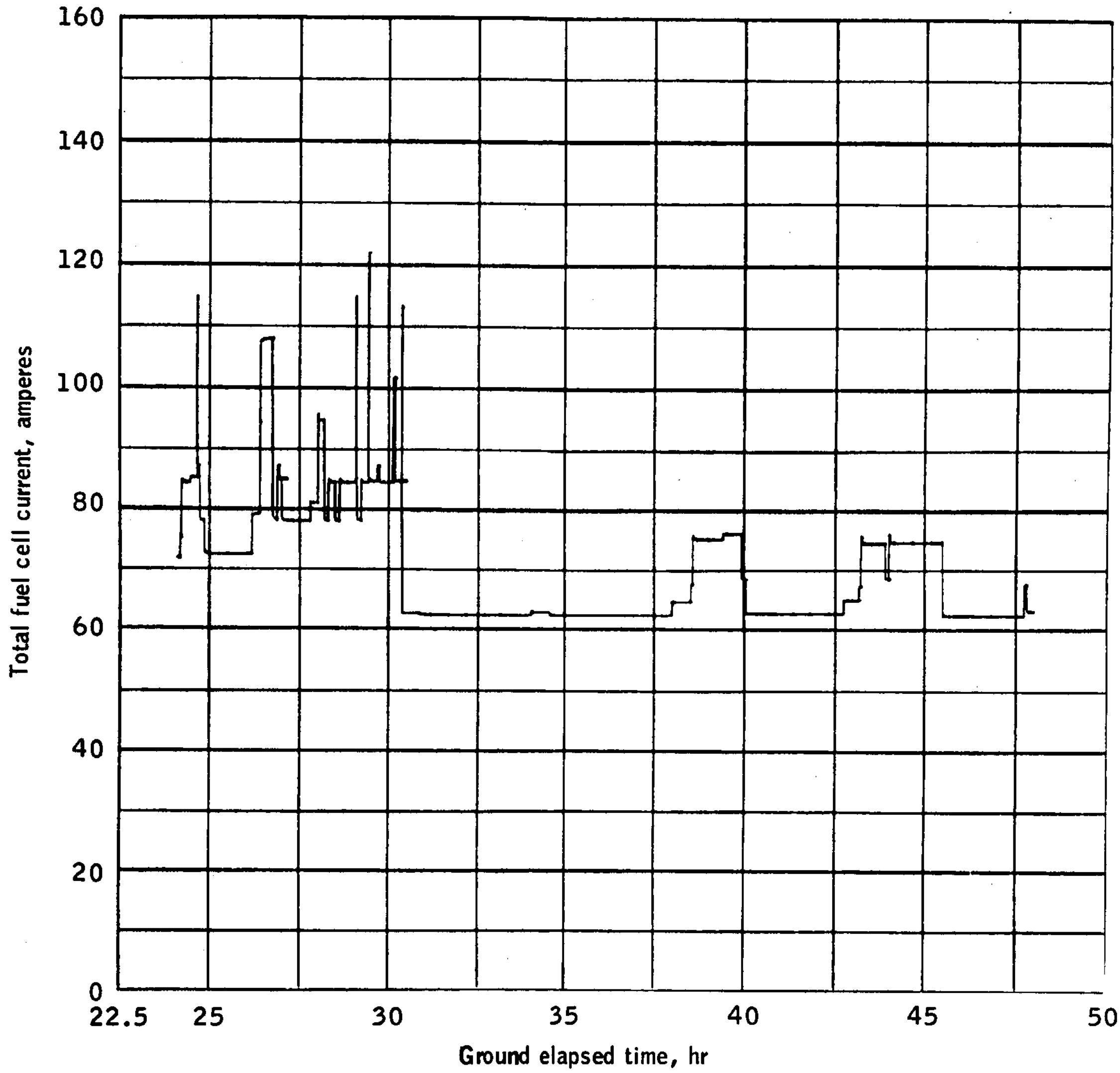
(k) 240 hours to 260 hours, ground elapsed time.

Figure 7.- Concluded.



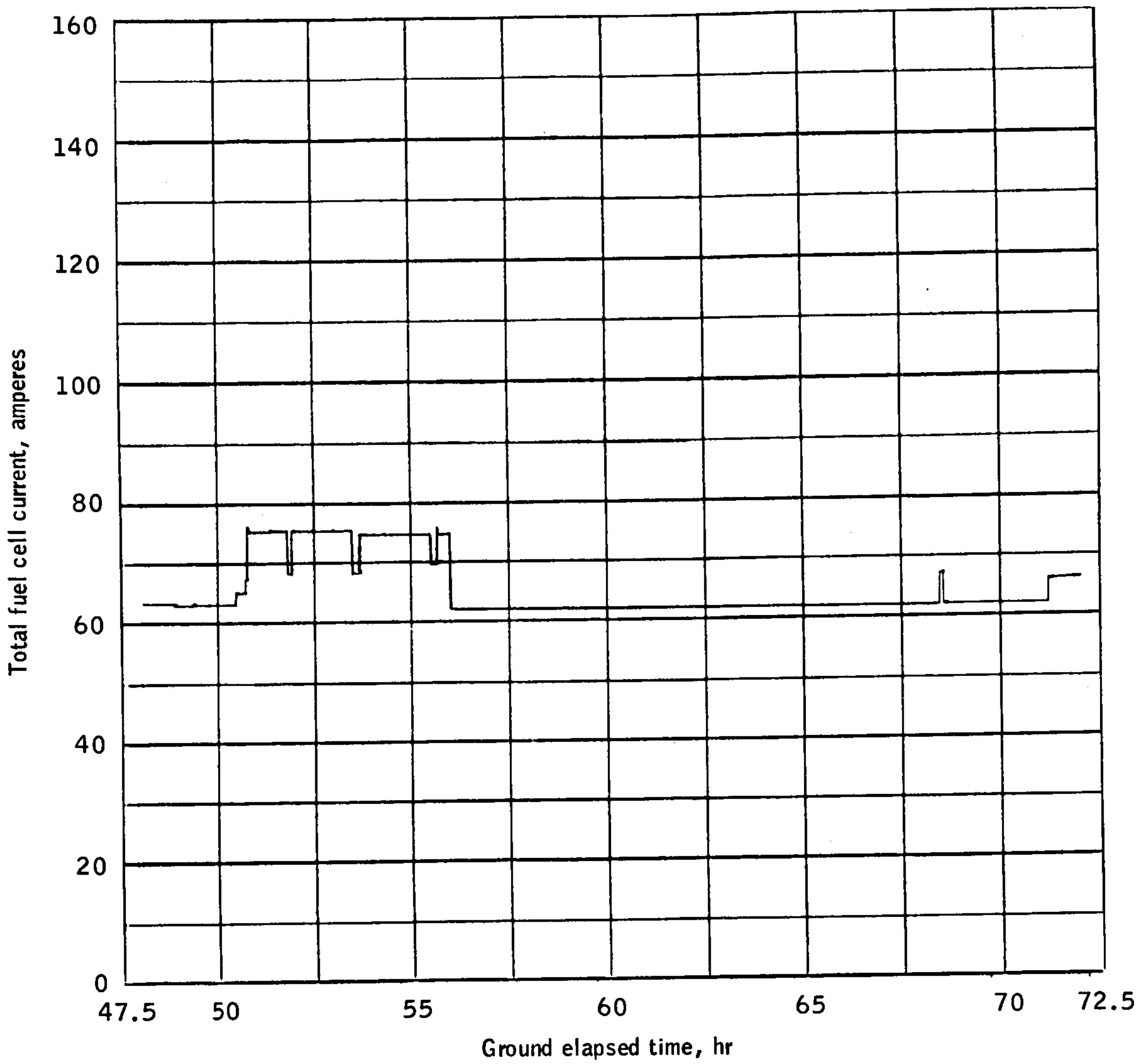
(a) Lift-off to 24 hours, ground elapsed time.

Figure 8.- Time history of total fuel cell current.



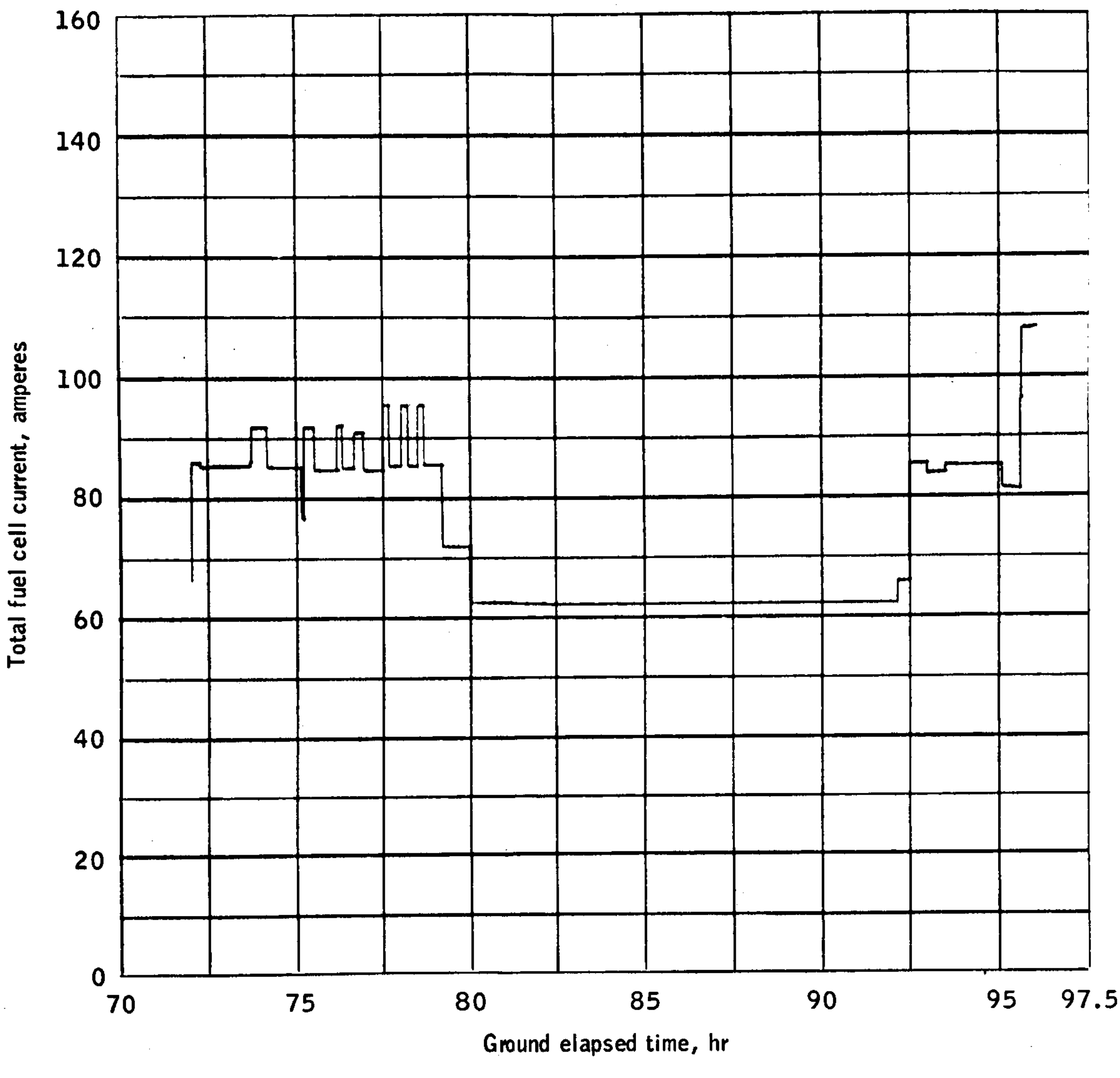
(b) 24 hours to 48 hours, ground elapsed time.

Figure 8.- Continued.



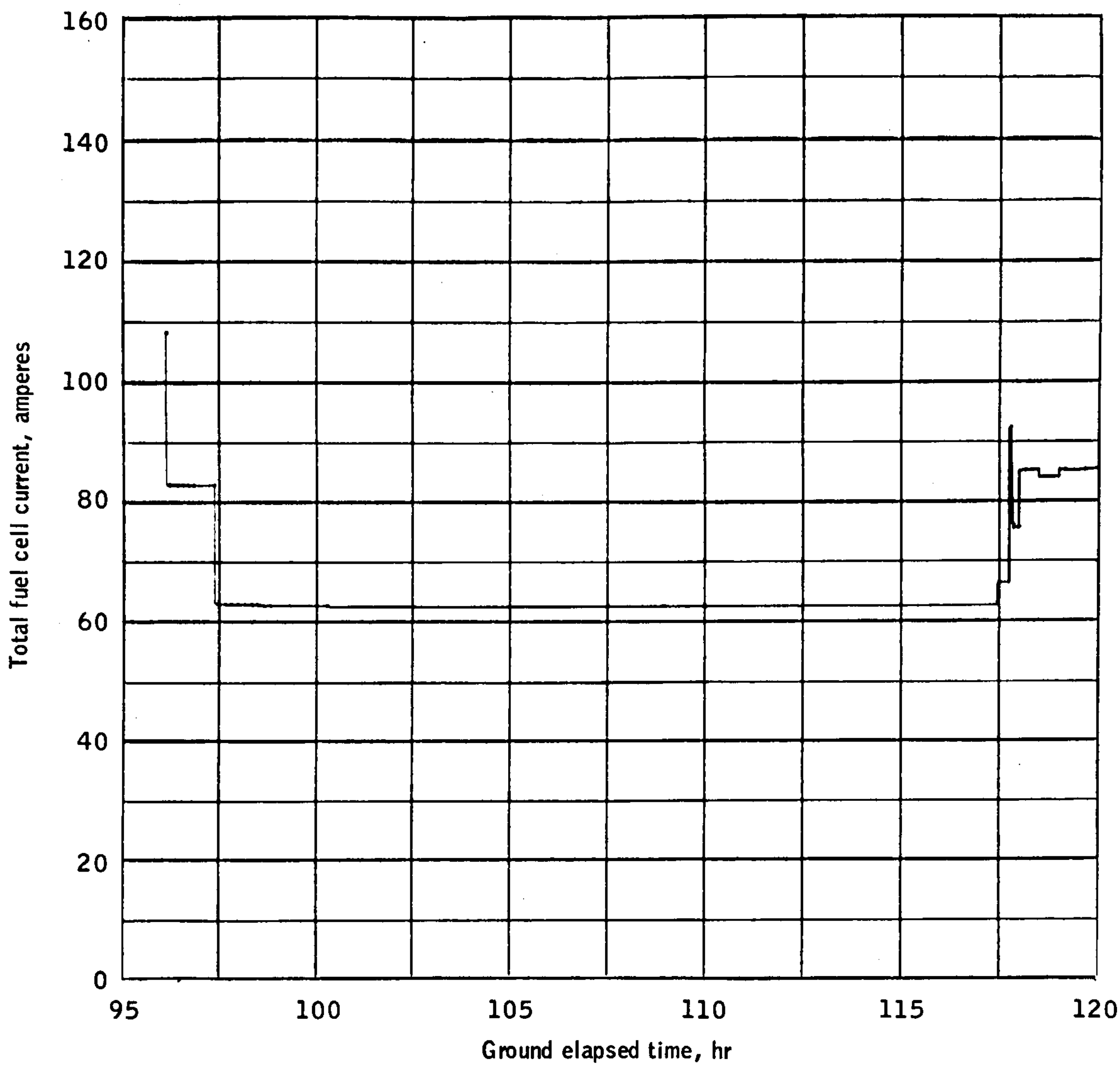
(c) 48 hours to 72 hours, ground elapsed time.

Figure 8.- Continued.



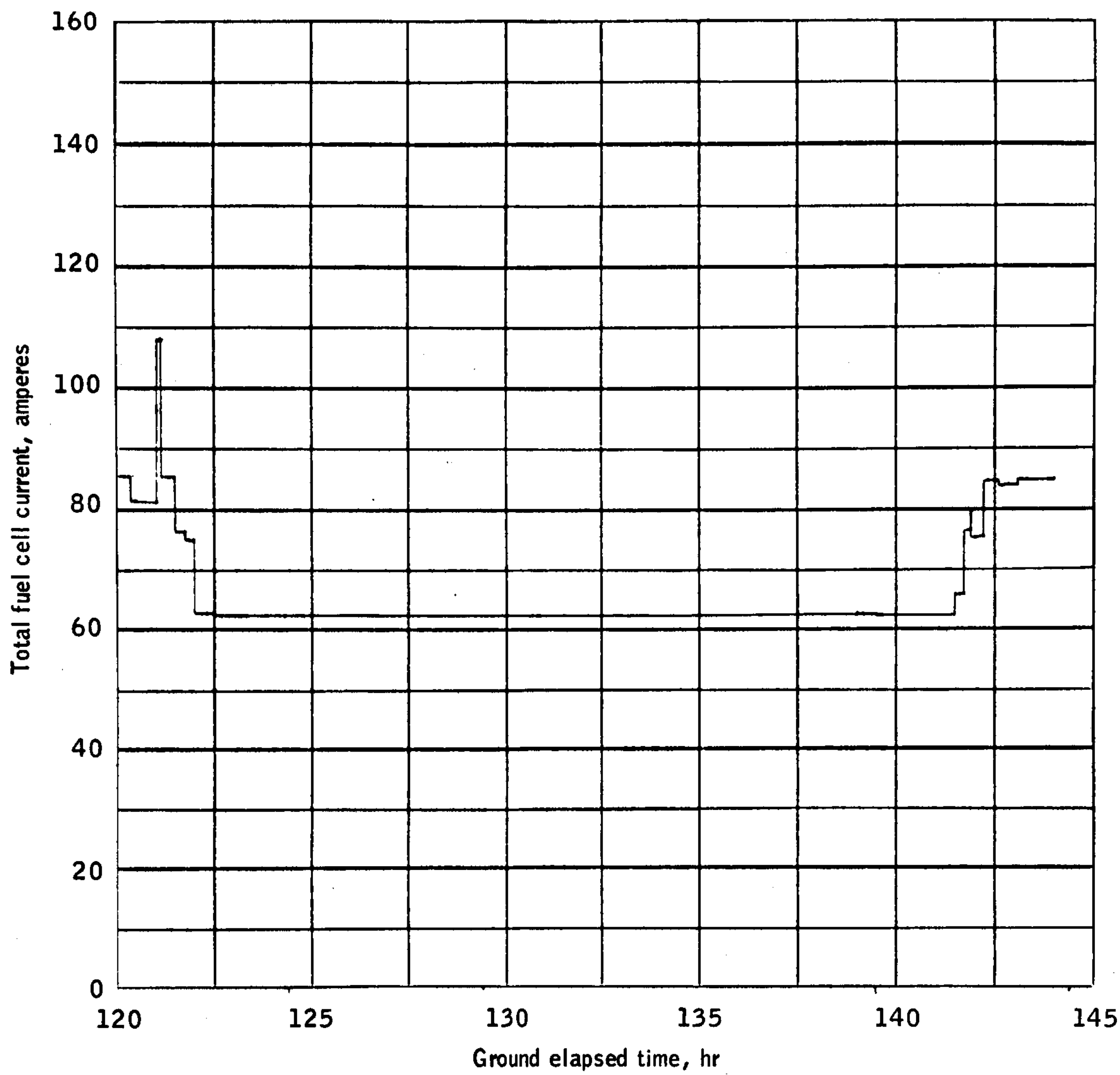
(d) 72 hours to 96 hours, ground elapsed time.

Figure 8.- Continued.



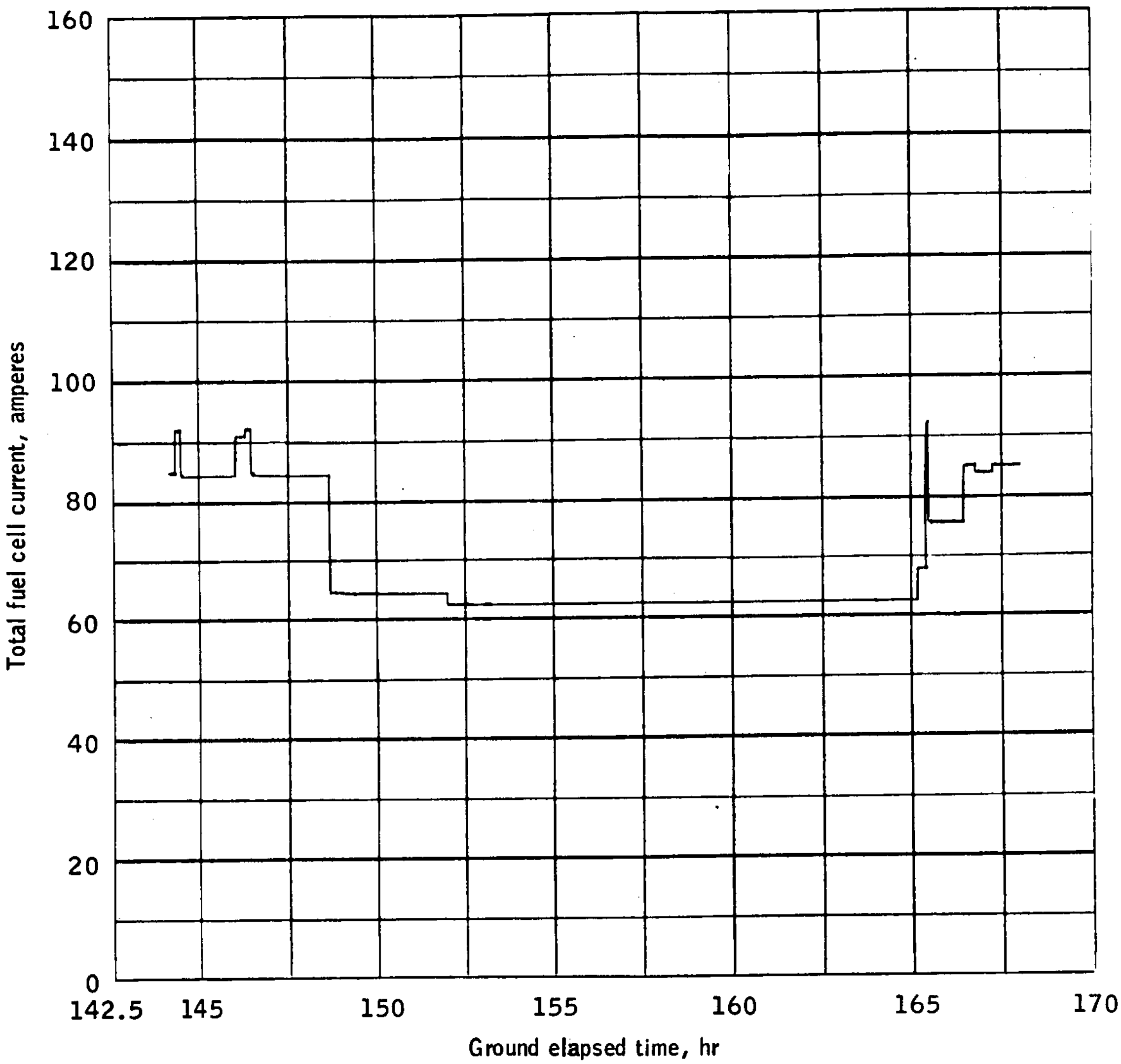
(e) 96 hours to 120 hours, ground elapsed time.

Figure 8.- Continued.



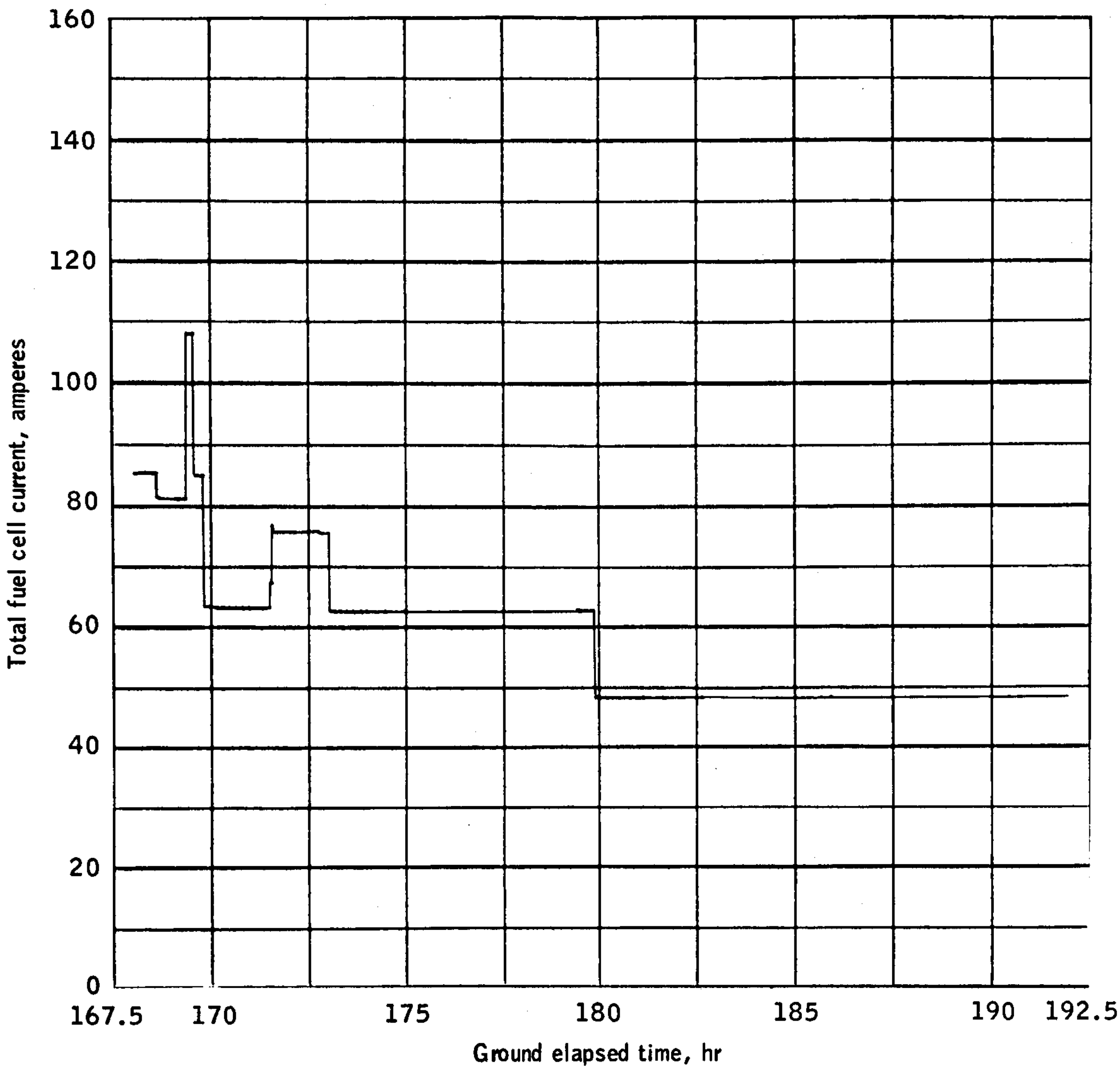
(f) 120 hours to 144 hours, ground elapsed time.

Figure 8.- Continued.



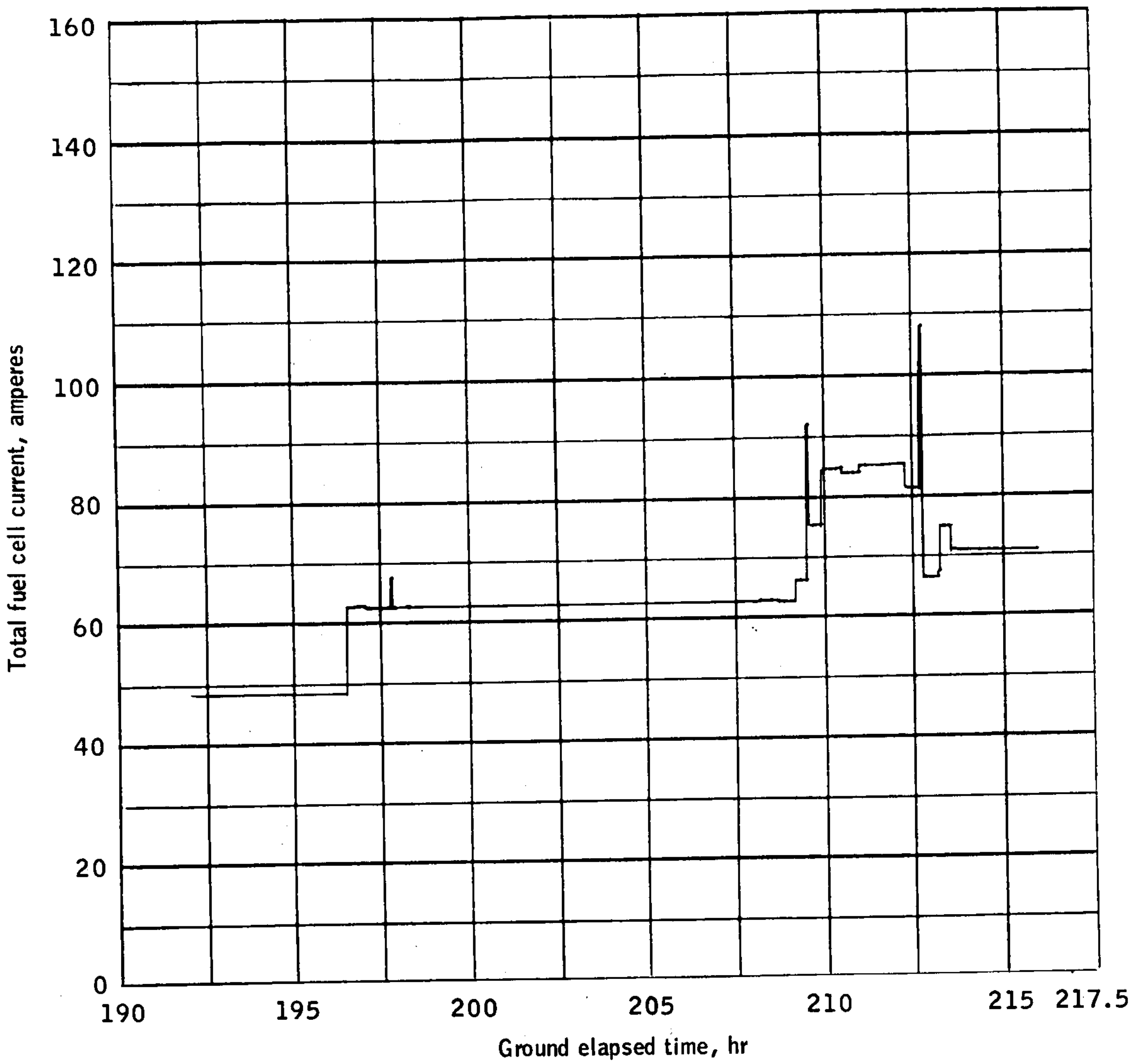
(g) 144 hours to 168 hours, ground elapsed time.

Figure 8.- Continued.



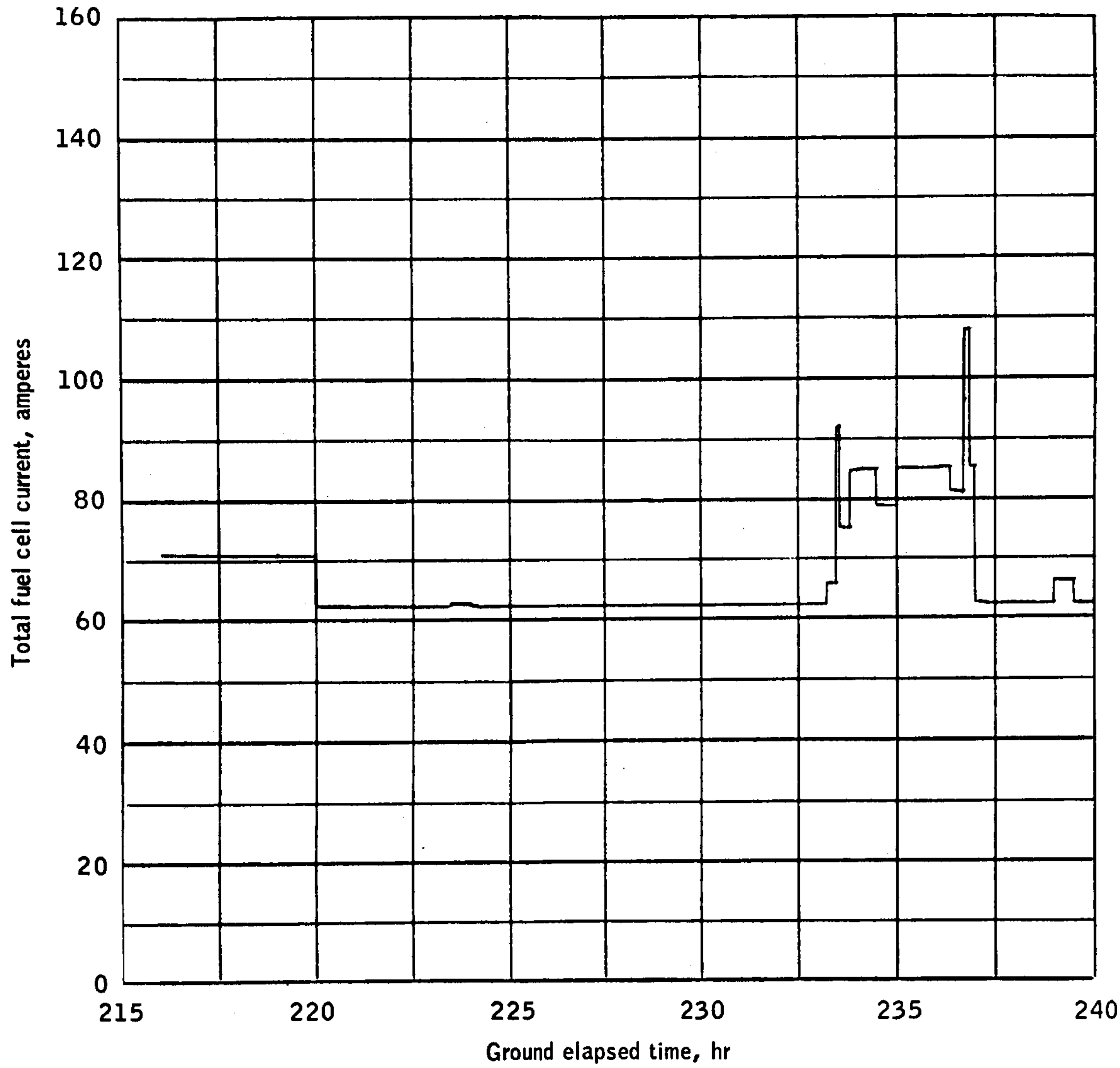
(h) 168 hours to 192 hours, ground elapsed time.

Figure 8.- Continued.



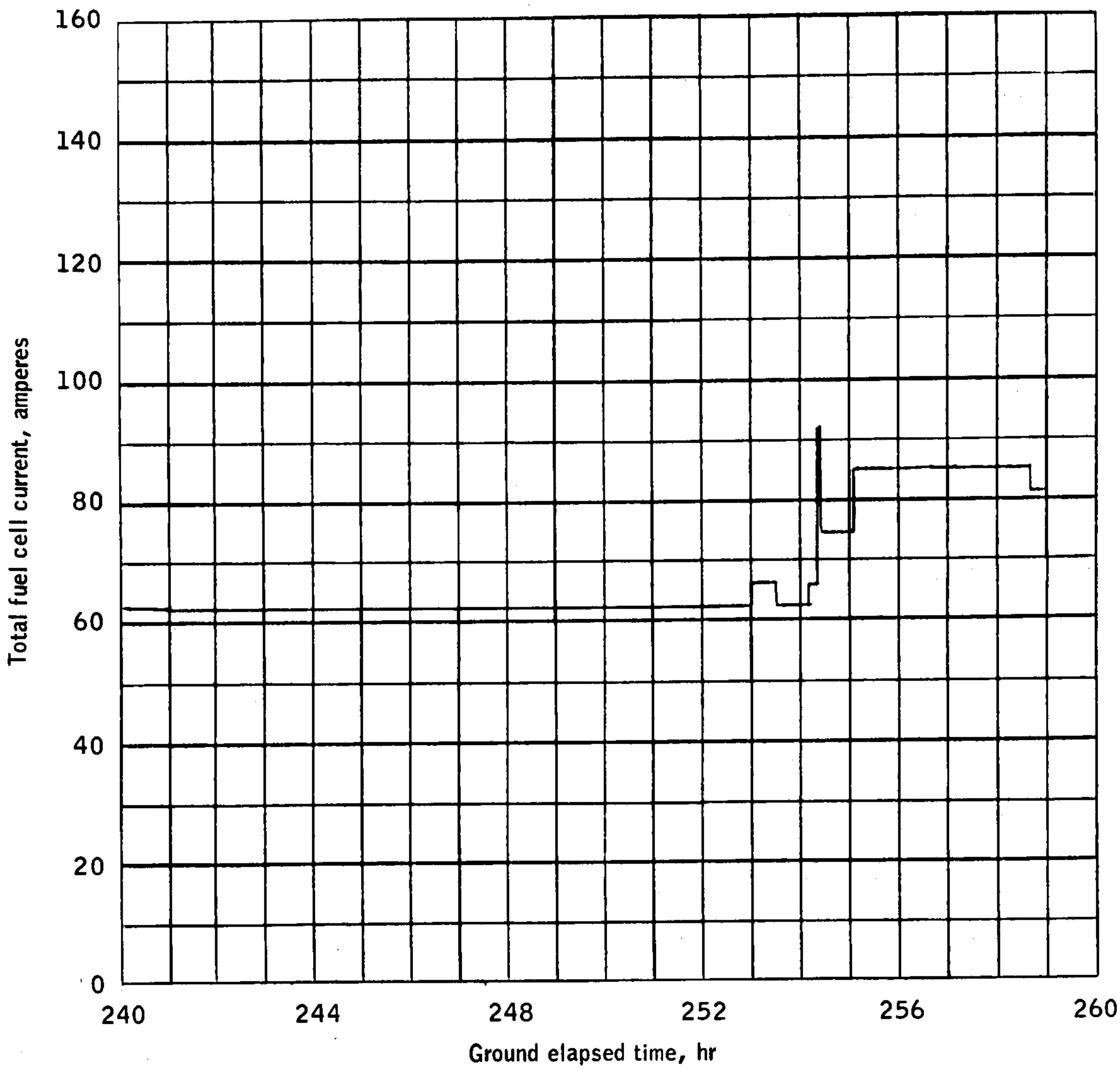
(i) 192 hours to 216 hours, ground elapsed time.

Figure 8.- Continued.



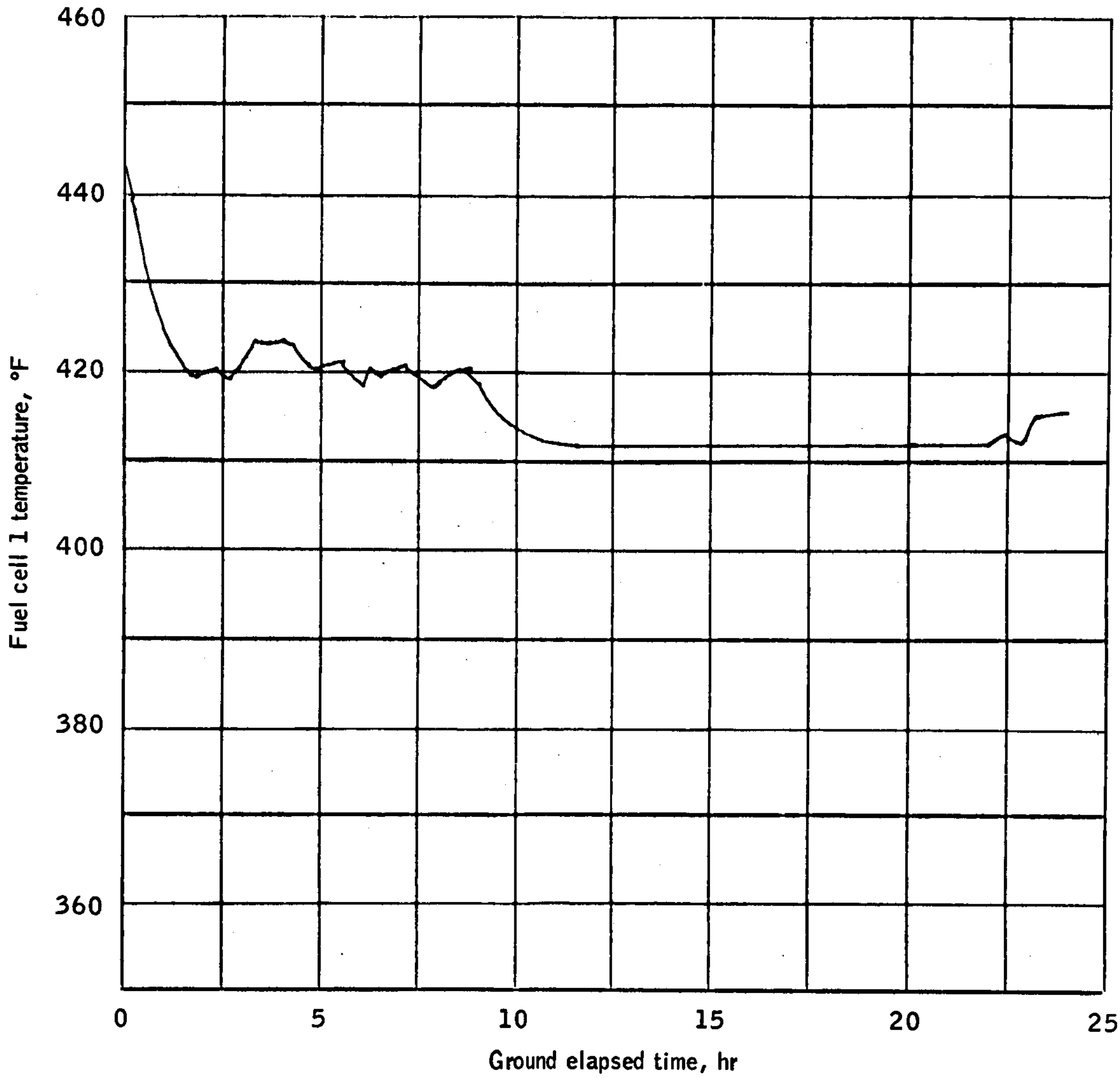
(j) 216 hours to 240 hours, ground elapsed time.

Figure 8.- Continued.



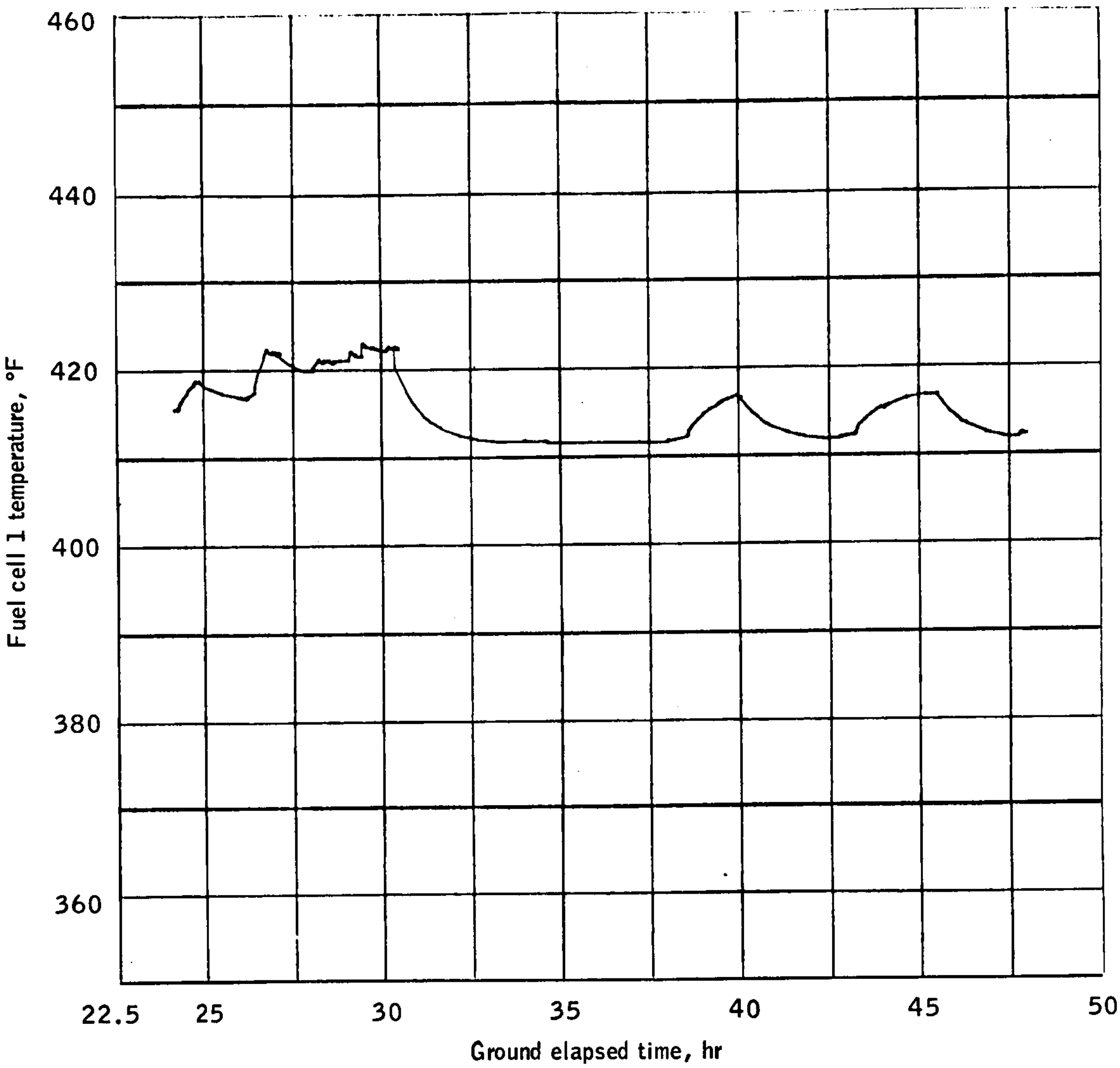
(k) 240 hours to 260 hours, ground elapsed time.

Figure 8.- Concluded.



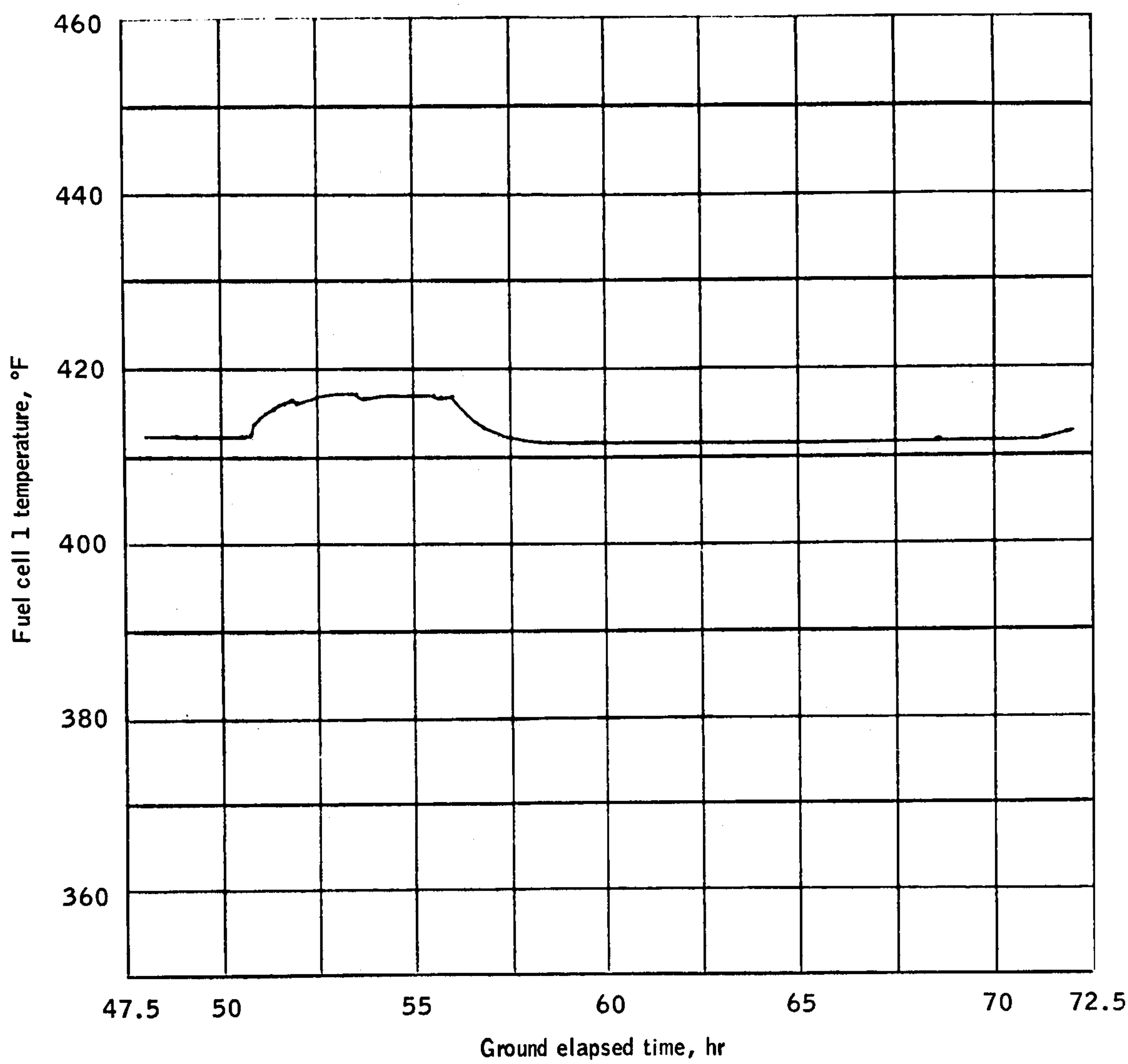
(a) Lift-off to 24 hours, ground elapsed time.

Figure 9.- Time history of fuel cell 1 temperature.



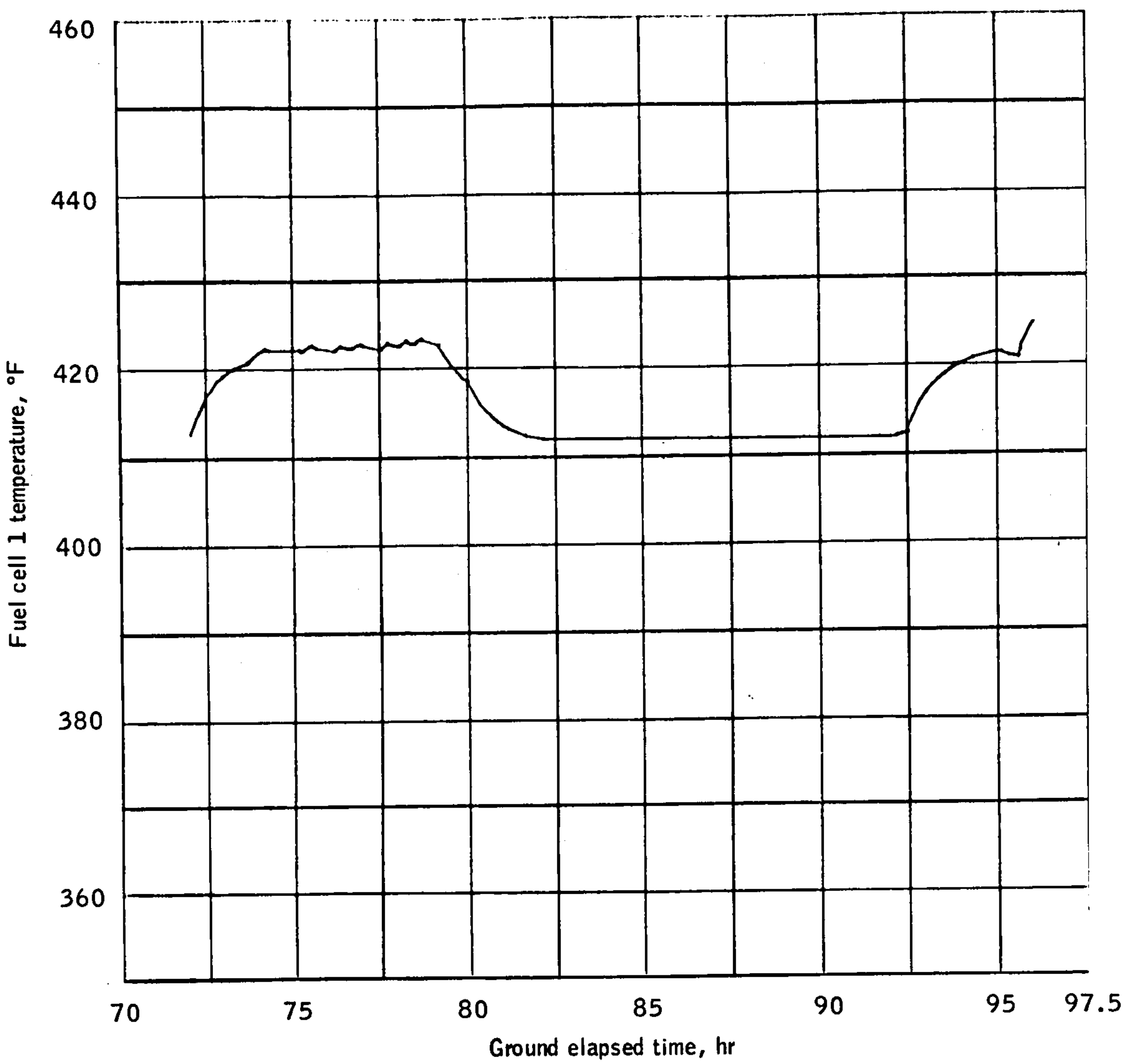
(b) 24 hours to 48 hours, ground elapsed time.

Figure 9.- Continued.



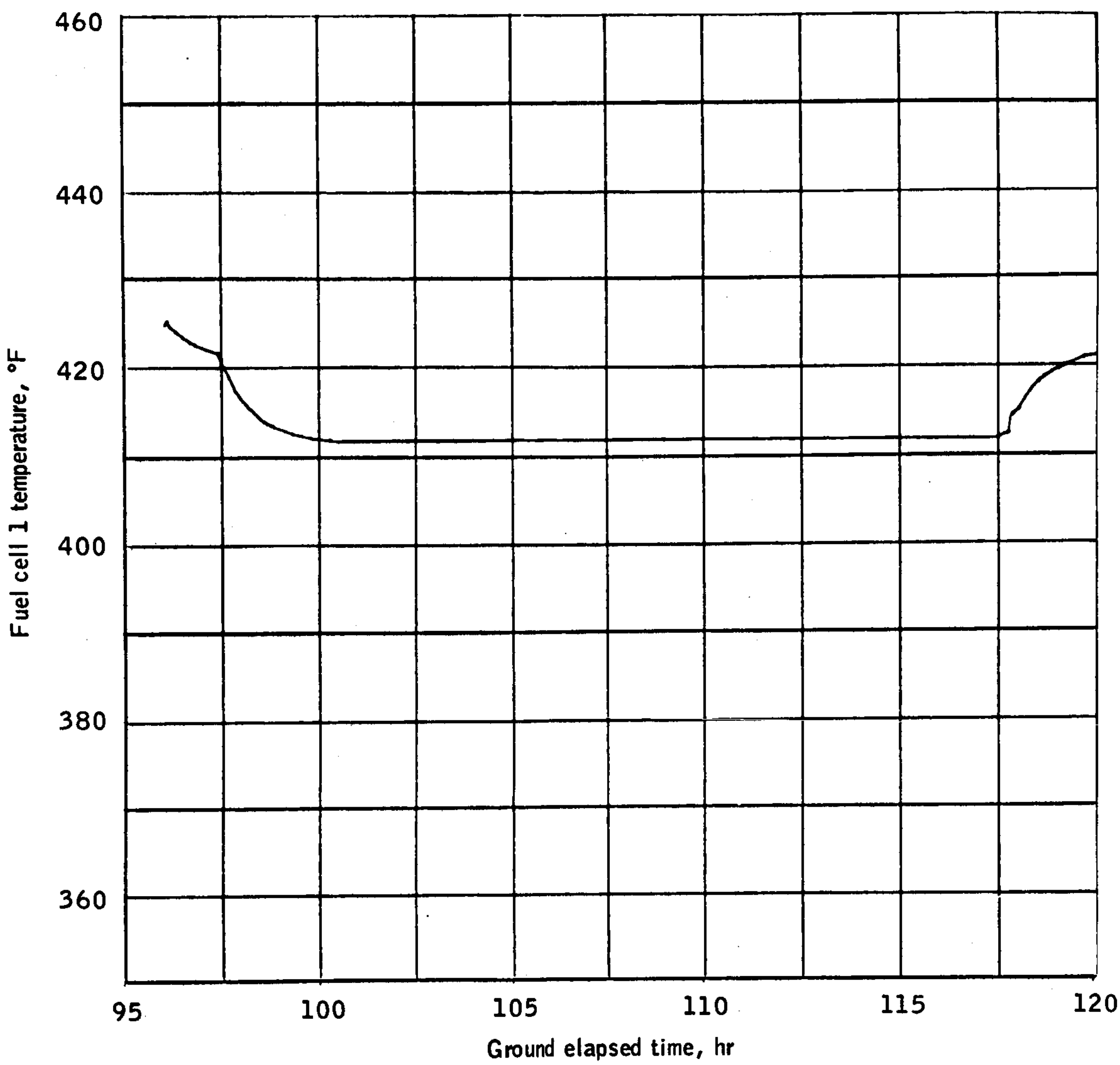
(c) 48 hours to 72 hours, ground elapsed time.

Figure 9.- Continued.



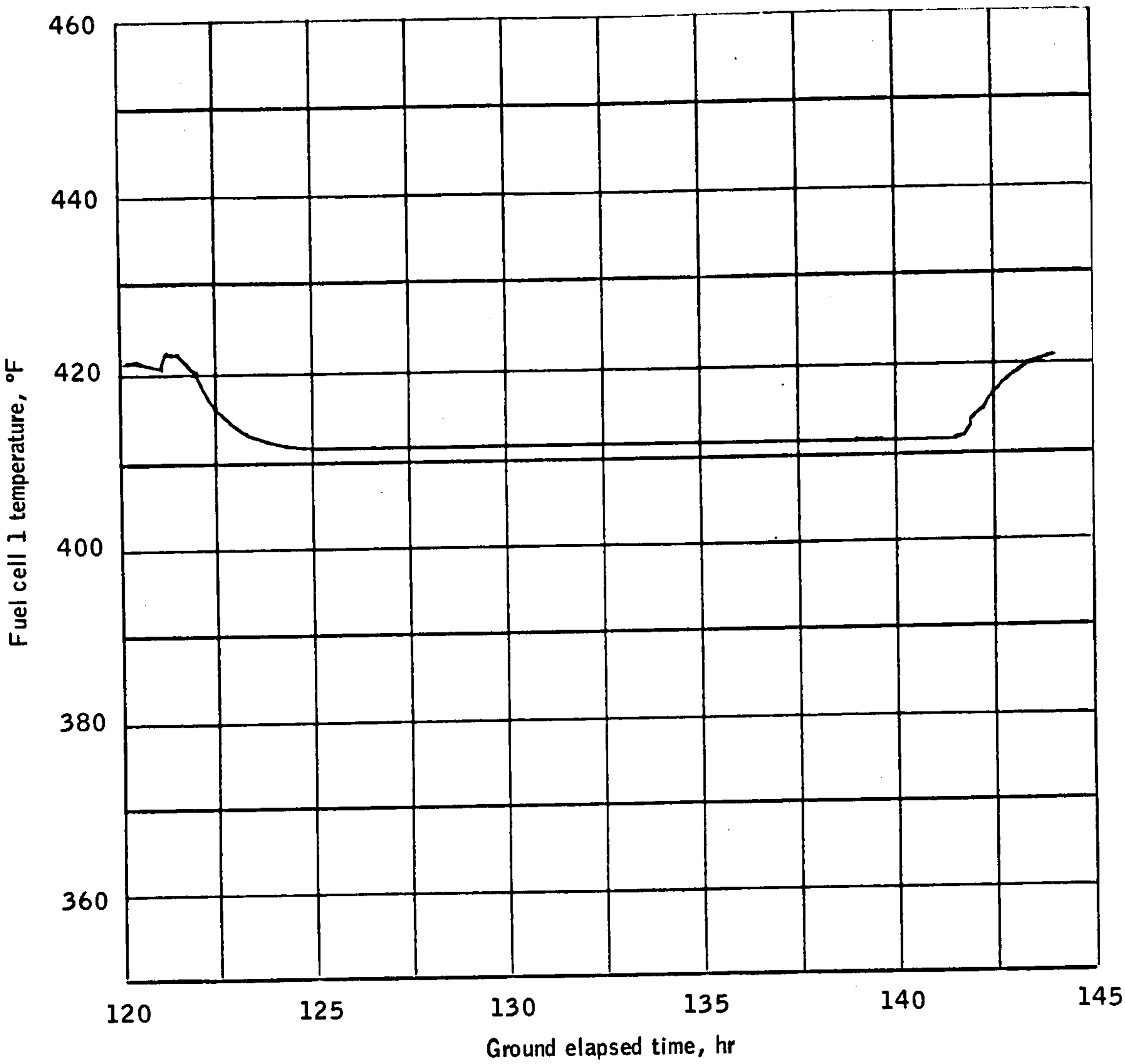
(d) 72 hours to 96 hours, ground elapsed time.

Figure 9.- Continued.



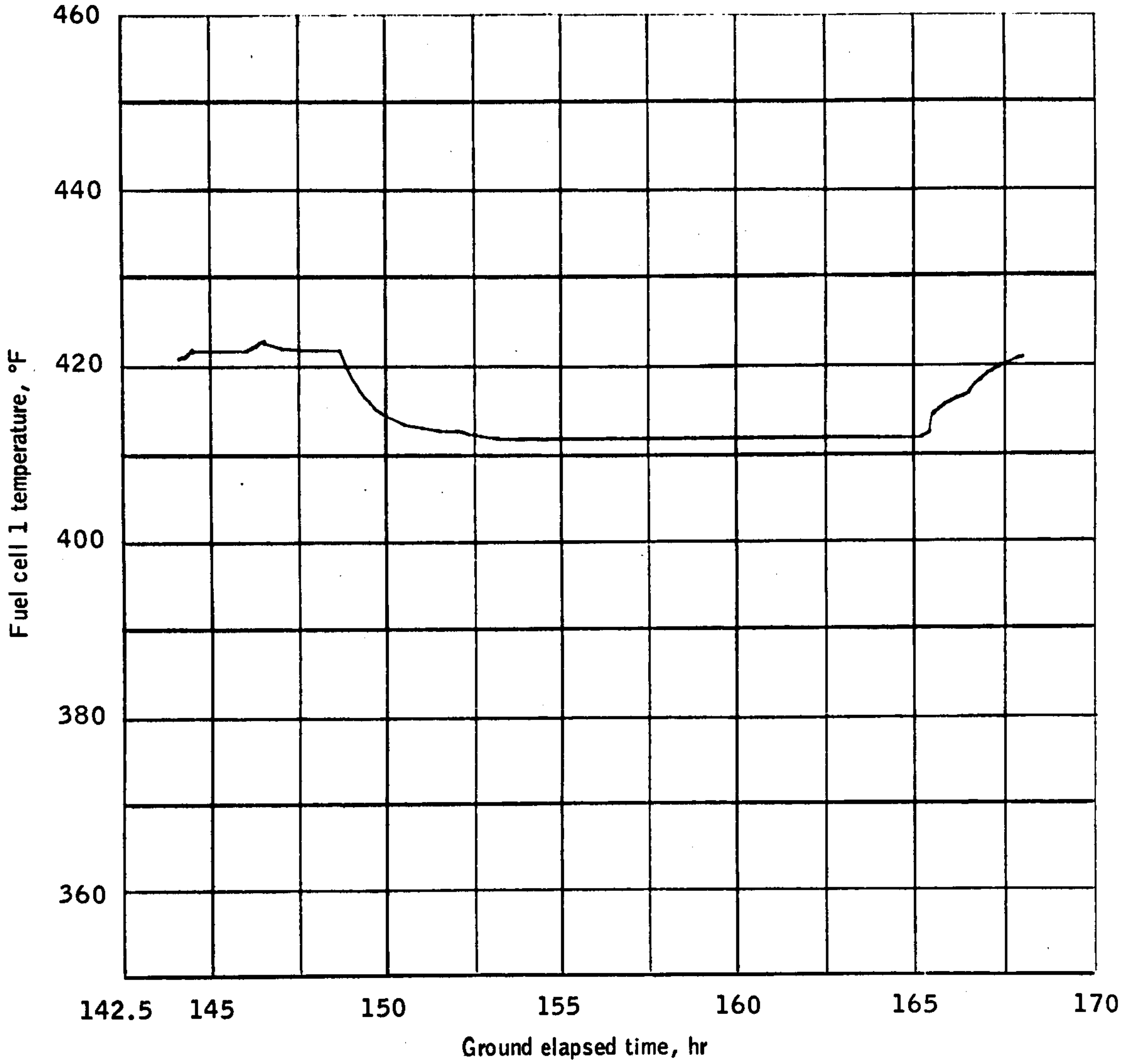
(e) 96 hours to 120 hours, ground elapsed time.

Figure 9.- Continued.



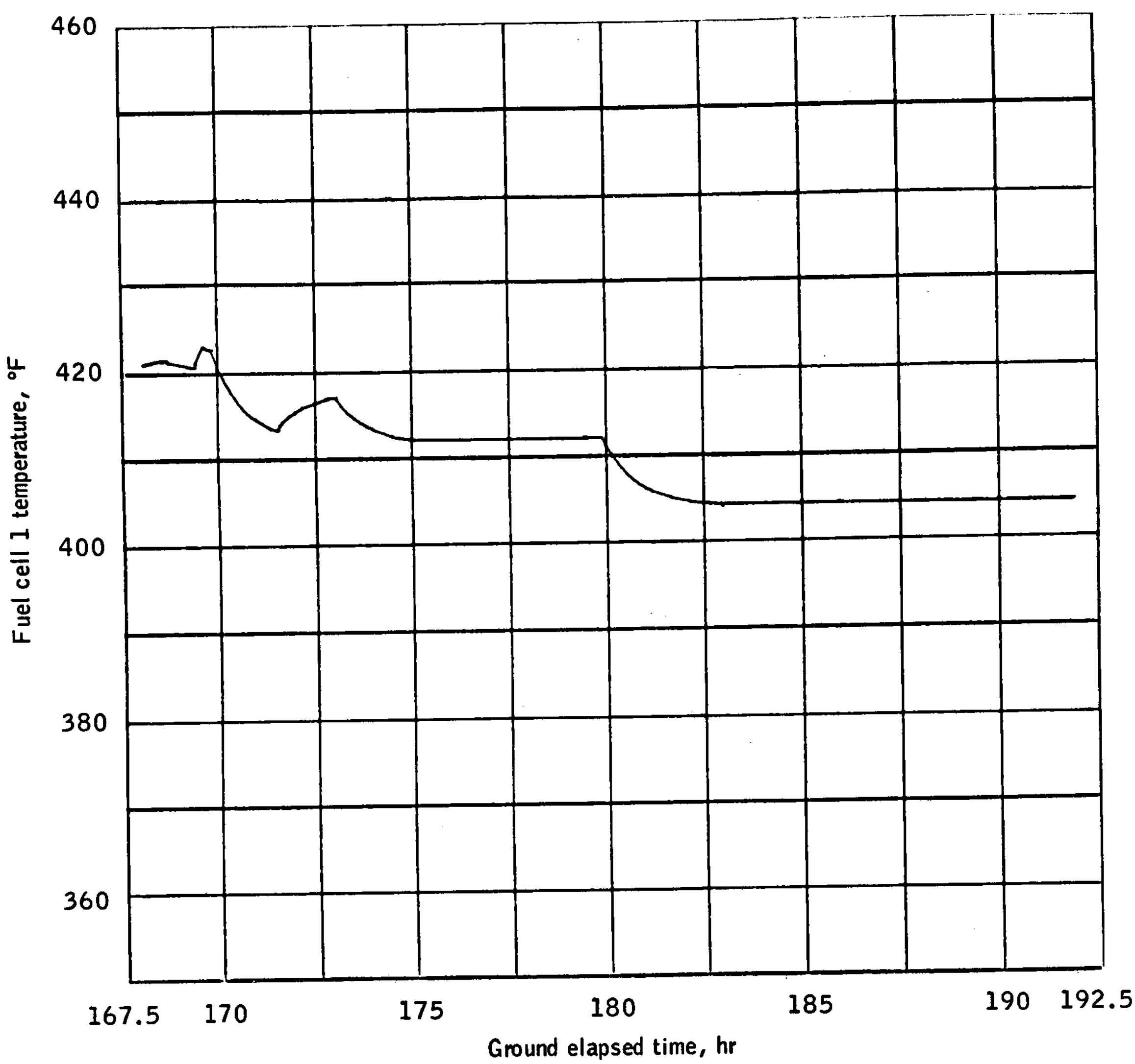
(f) 120 hours to 144 hours, ground elapsed time.

Figure 9.- Continued.



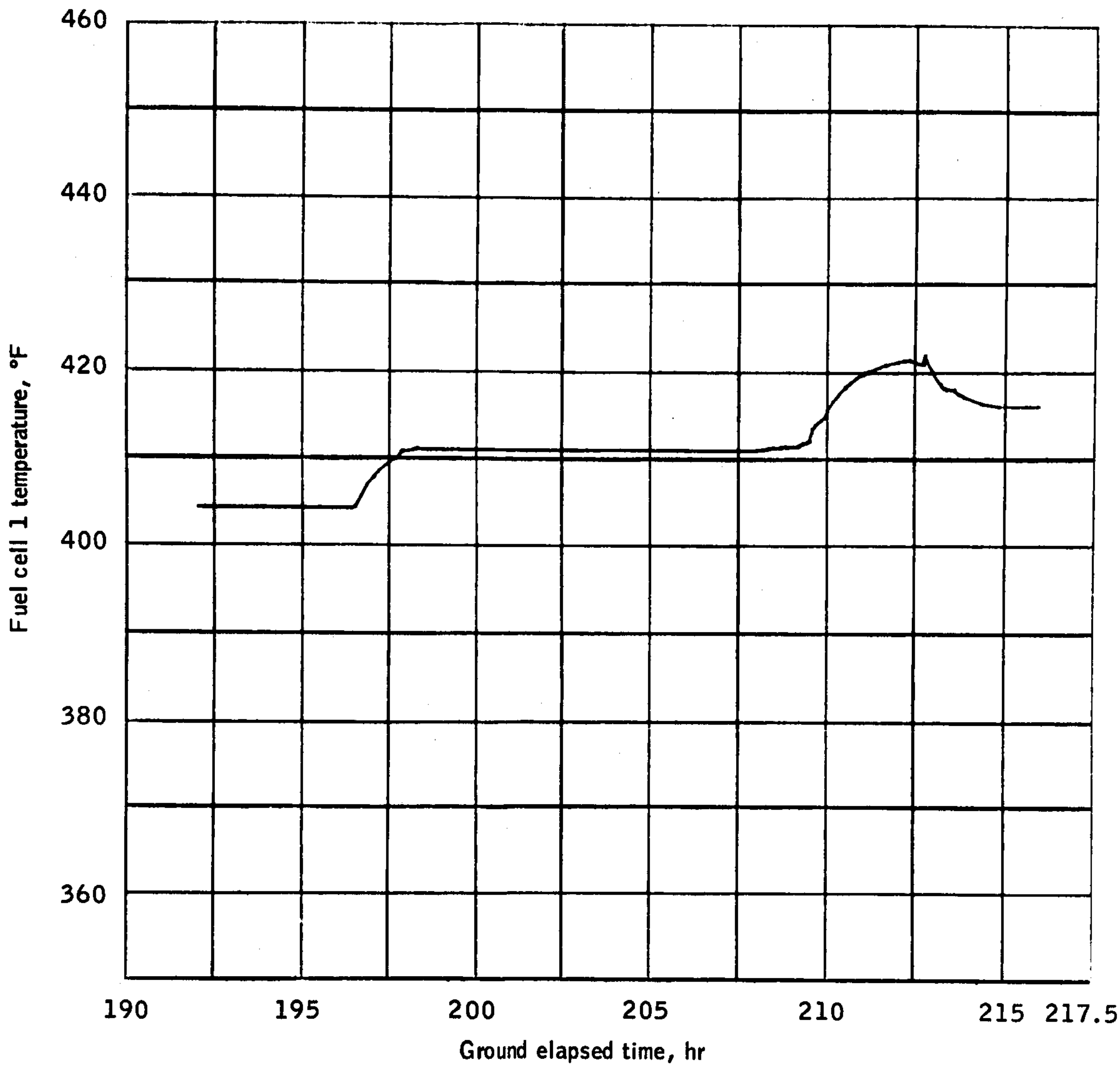
(g) 144 hours to 168 hours, ground elapsed time.

Figure 9.- Continued.



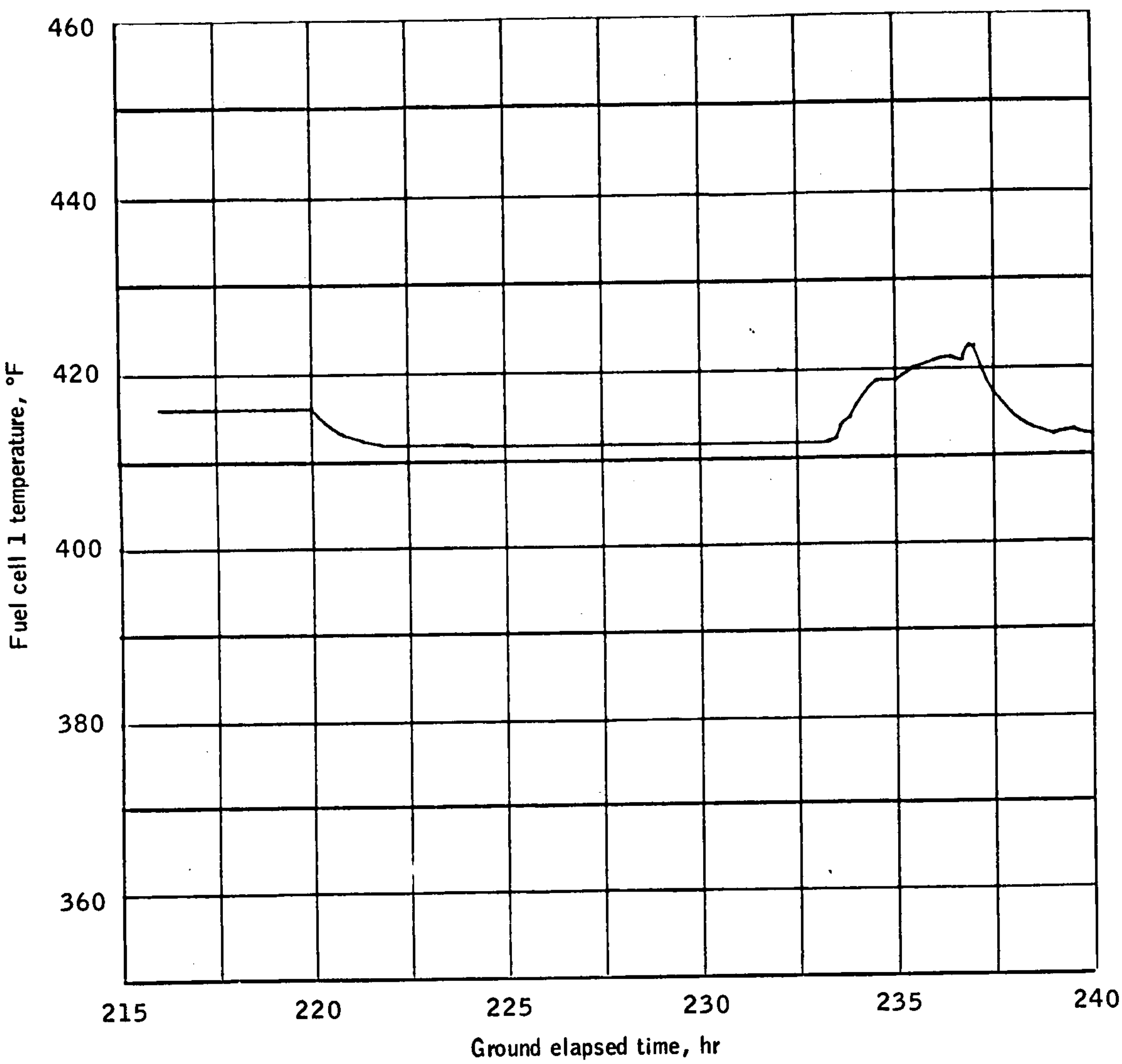
(h) 168 hours to 192 hours, ground elapsed time.

Figure 9.- Continued.



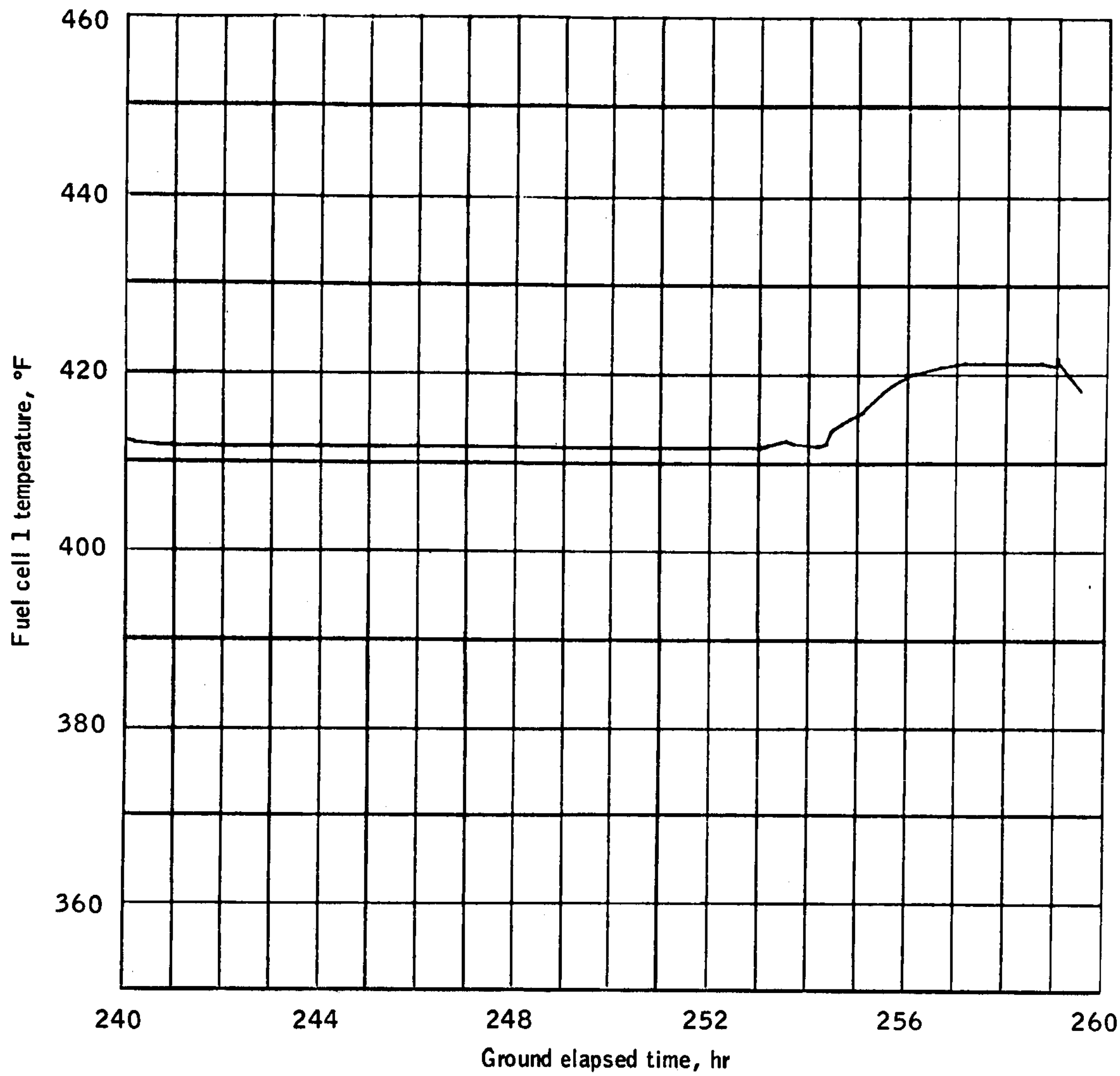
(i) 192 hours to 216 hours, ground elapsed time.

Figure 9.- Continued.



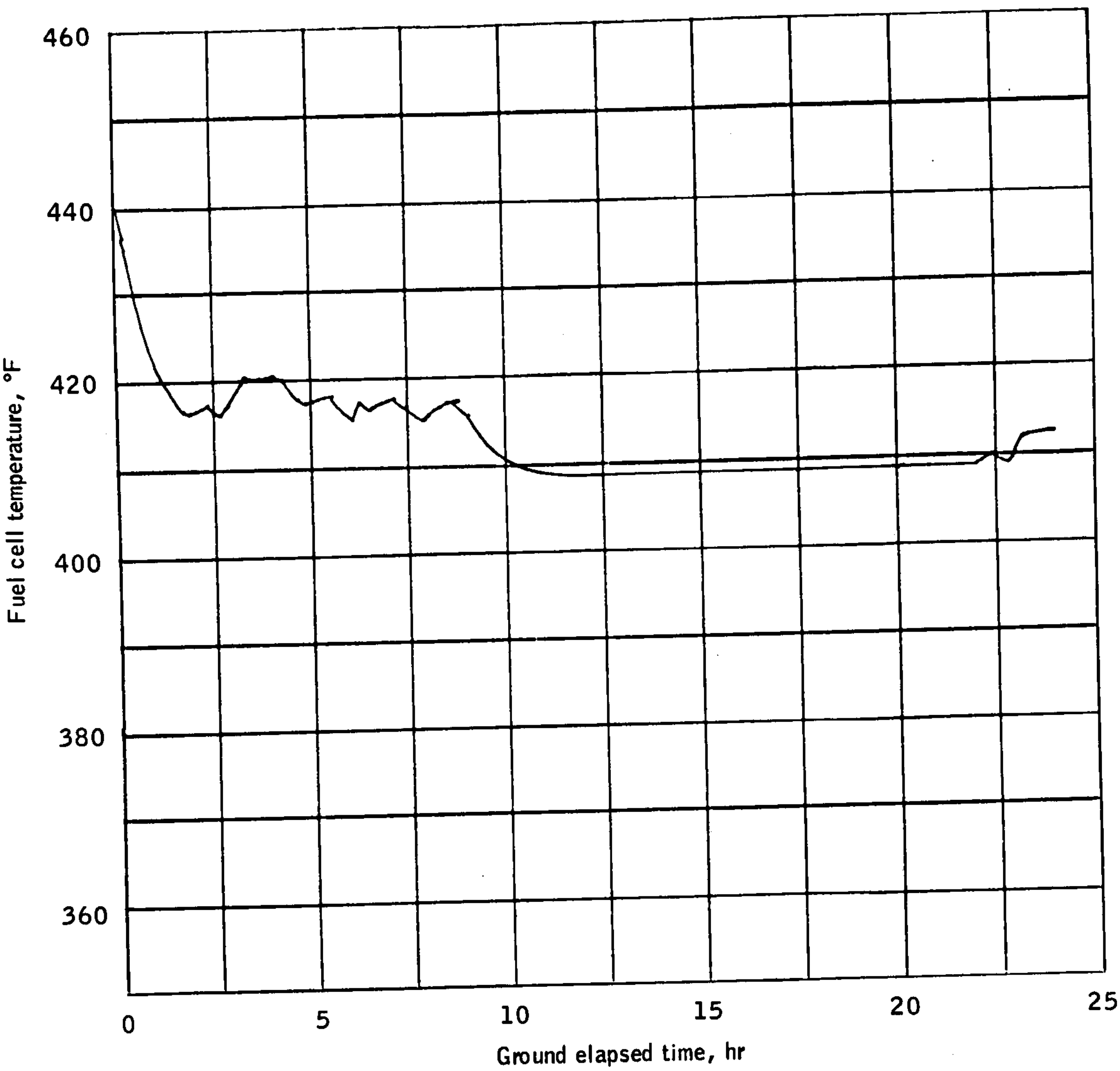
(j) 216 hours to 240 hours, ground elapsed time.

Figure 9.- Continued.



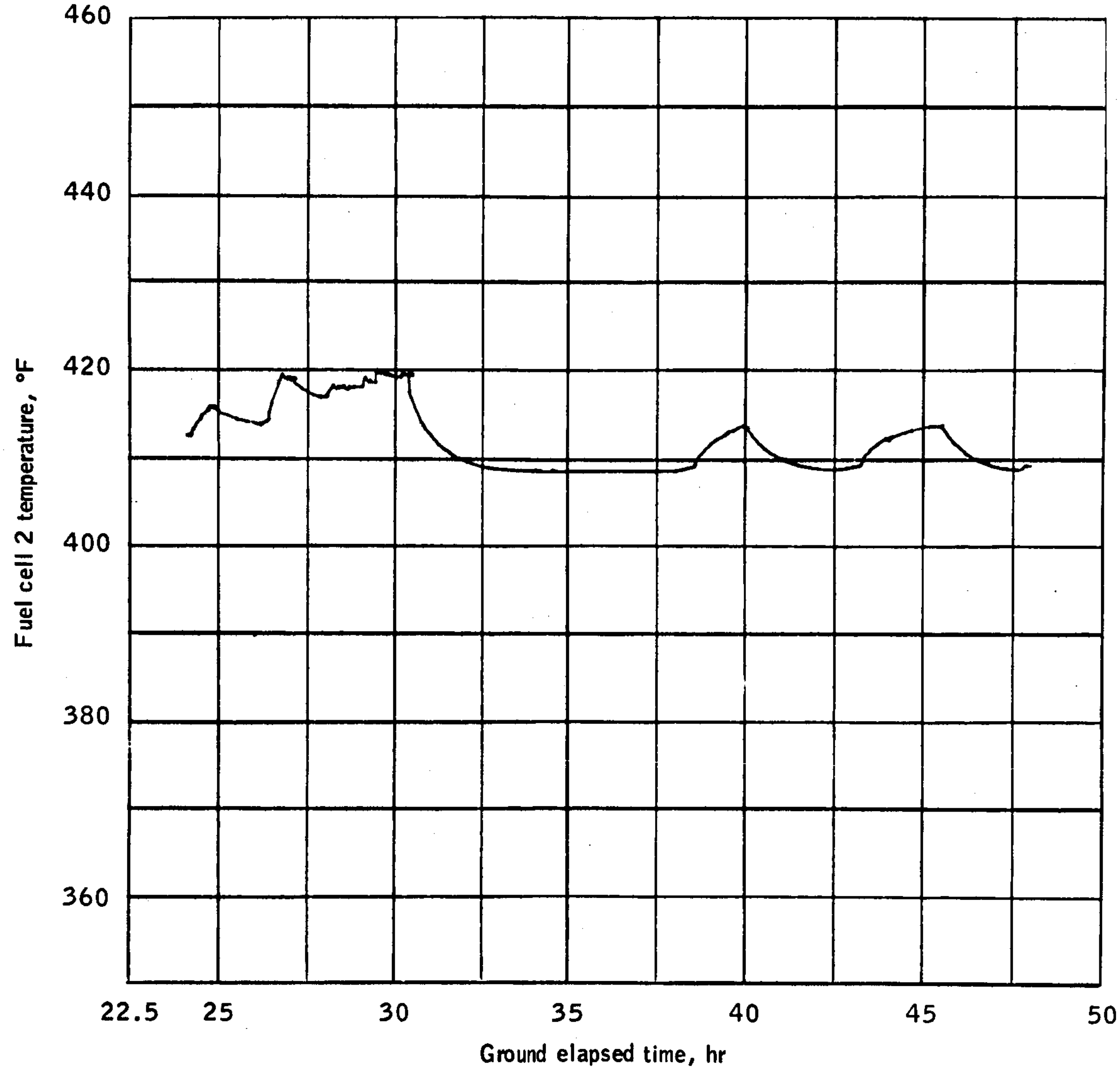
(k) 240 hours to 260 hours, ground elapsed time.

Figure 9.- Concluded.



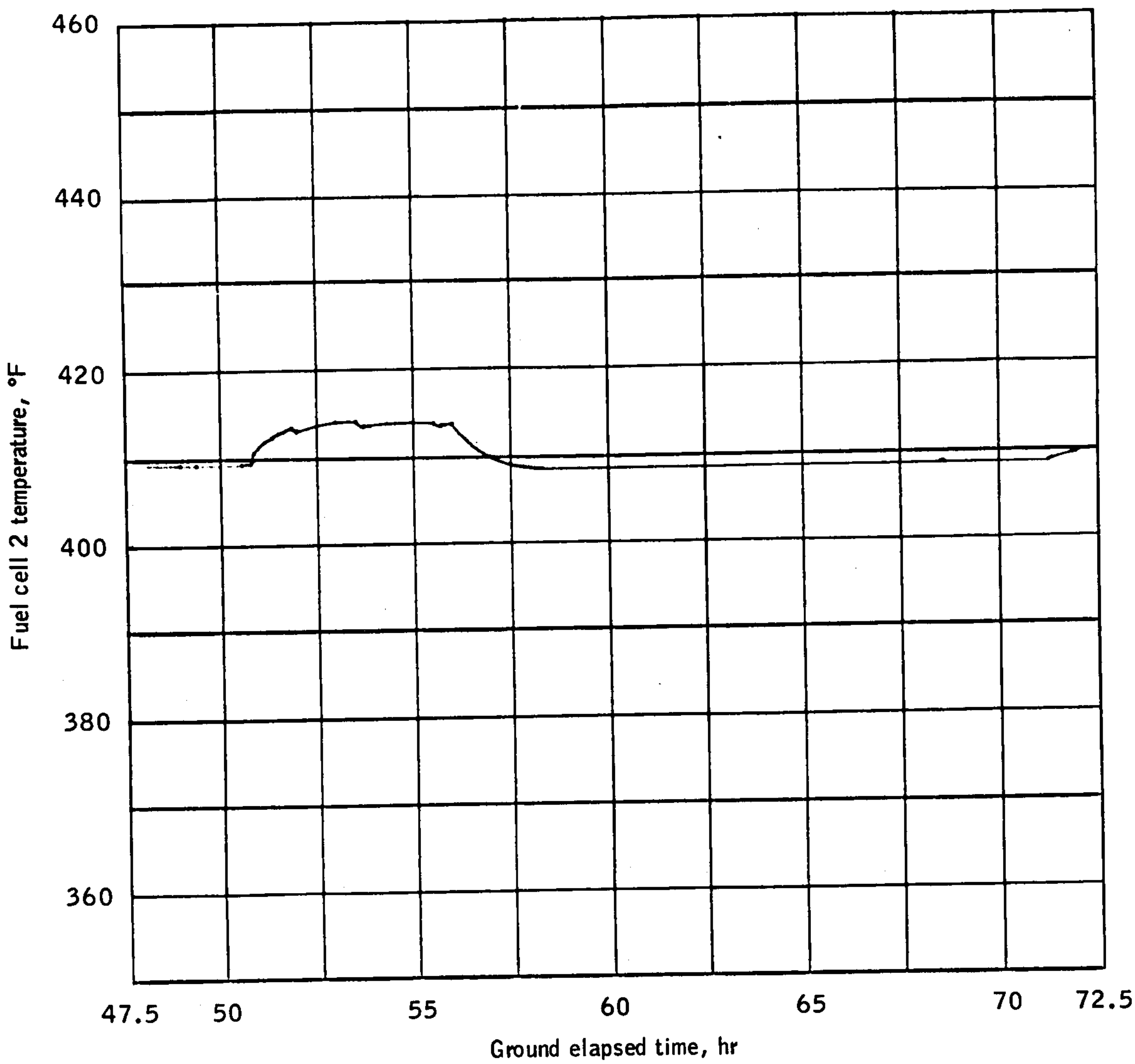
(a) Lift-off to 24 hours, ground elapsed time.

Figure 10.- Time history of fuel cell 2 temperature.



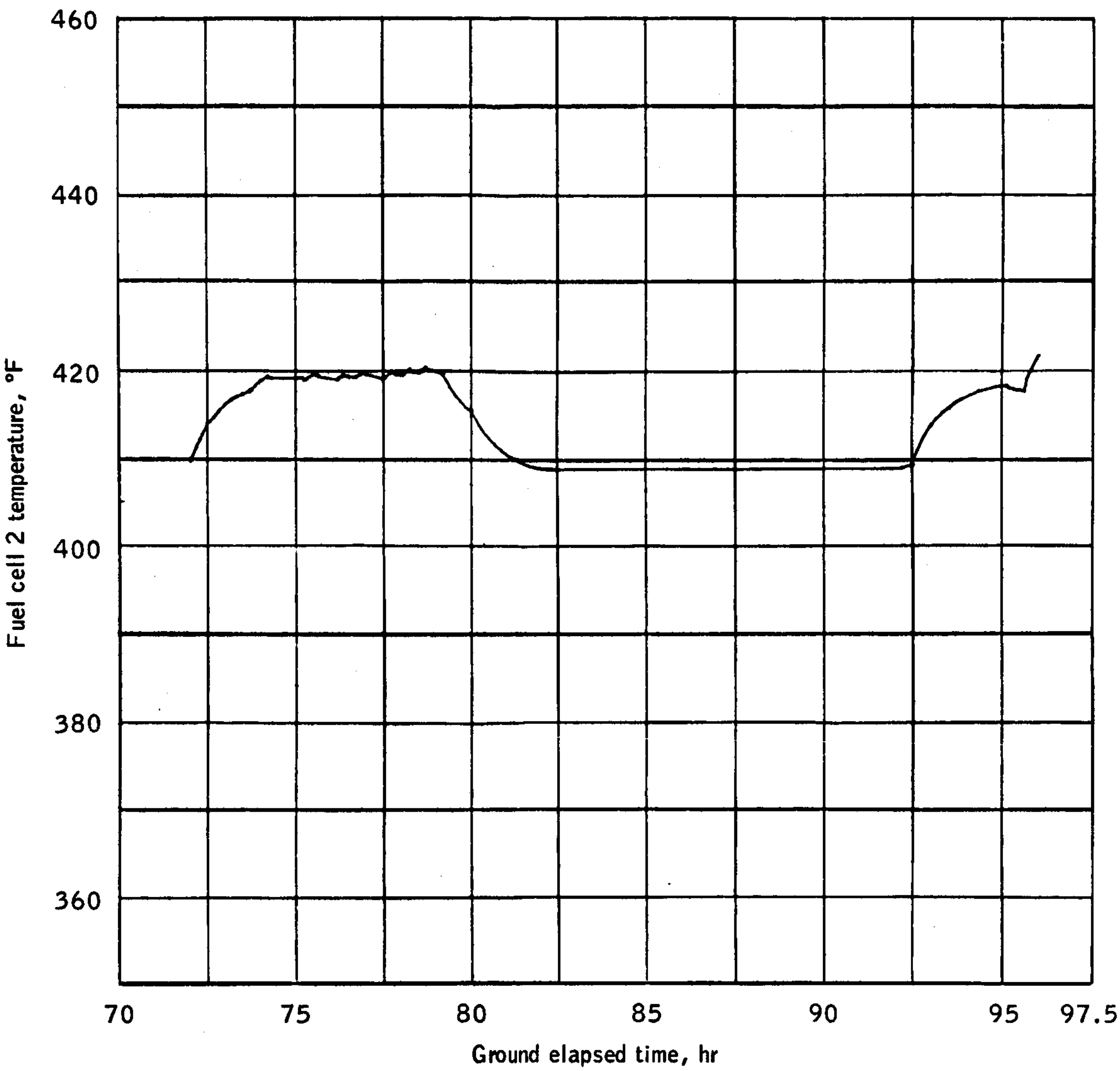
(b) 24 hours to 48 hours, ground elapsed time.

Figure 10.- Continued.



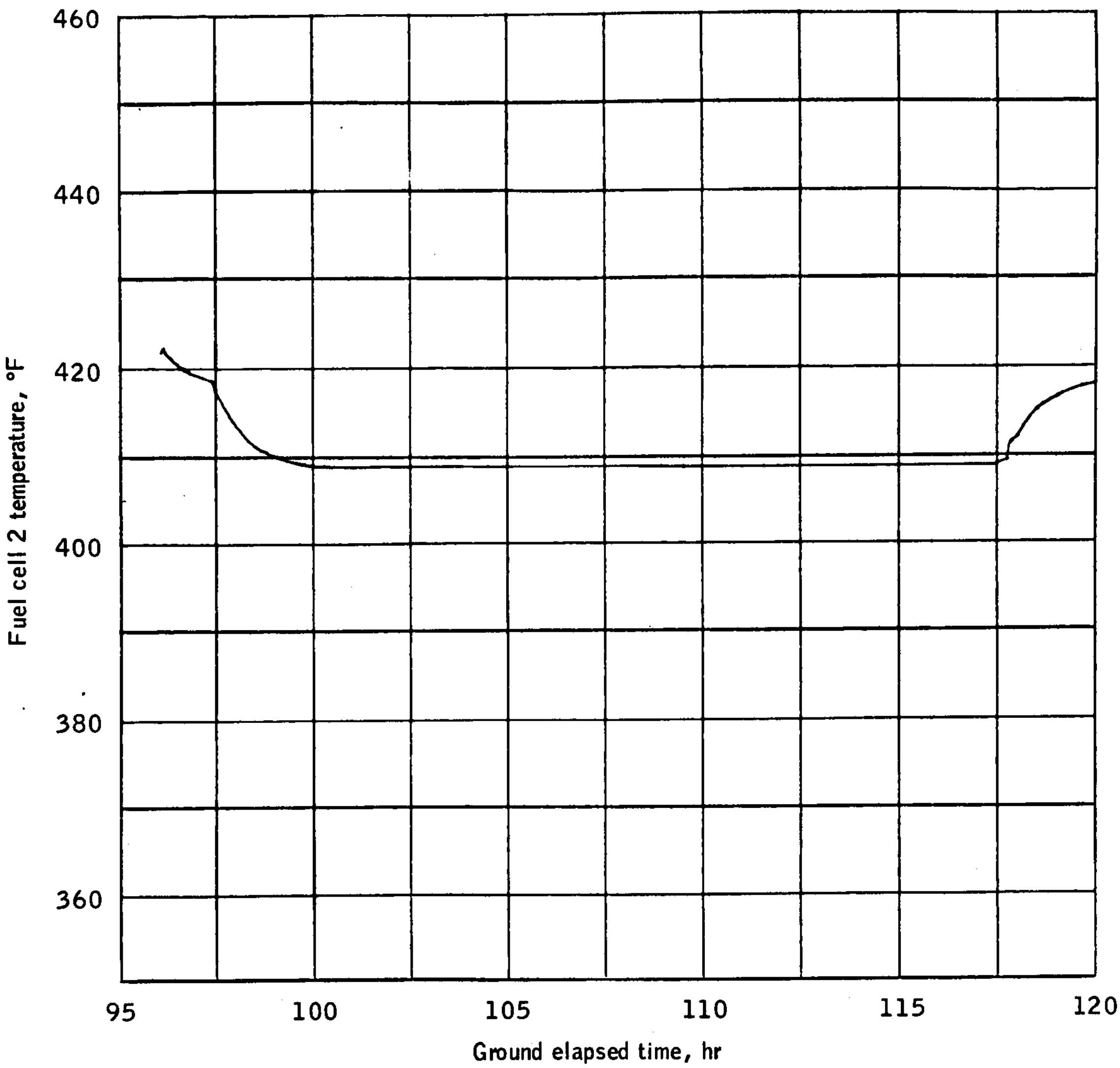
(c) 48 hours to 72 hours, ground elapsed time.

Figure 10.- Continued.



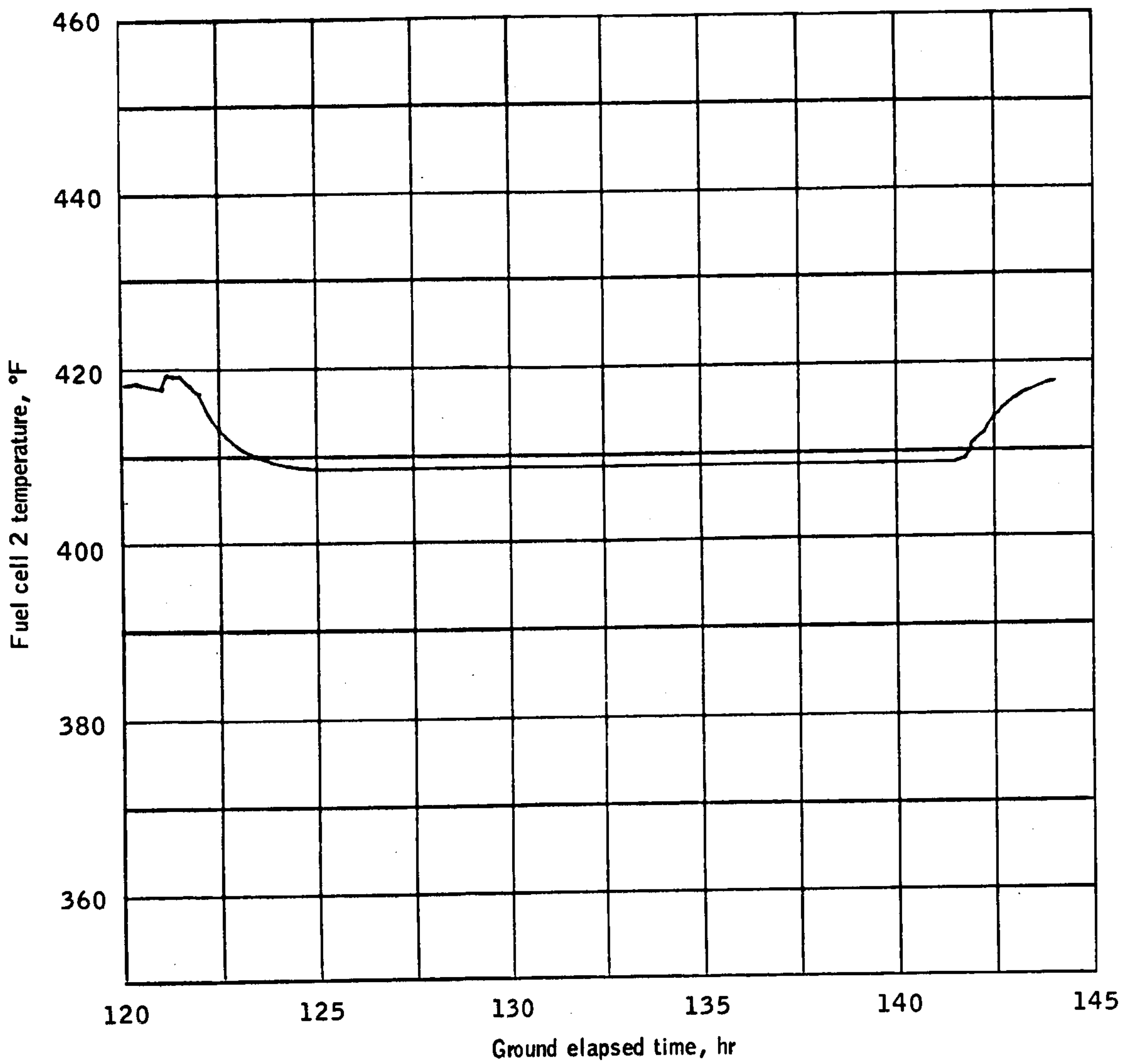
(d) 72 hours to 96 hours, ground elapsed time.

Figure 10.- Continued.



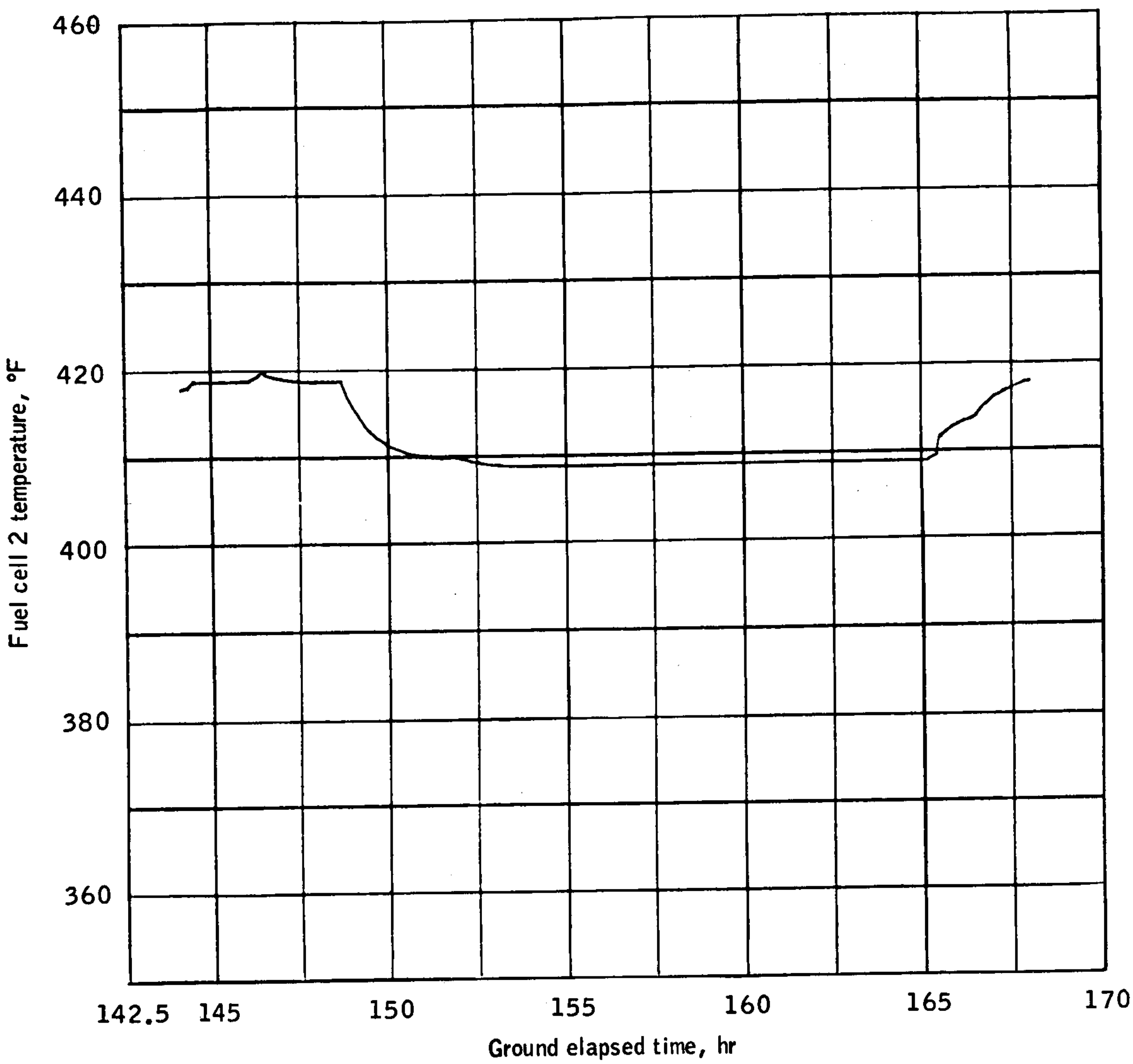
(e) 96 hours to 120 hours, ground elapsed time.

Figure 10.- Continued.



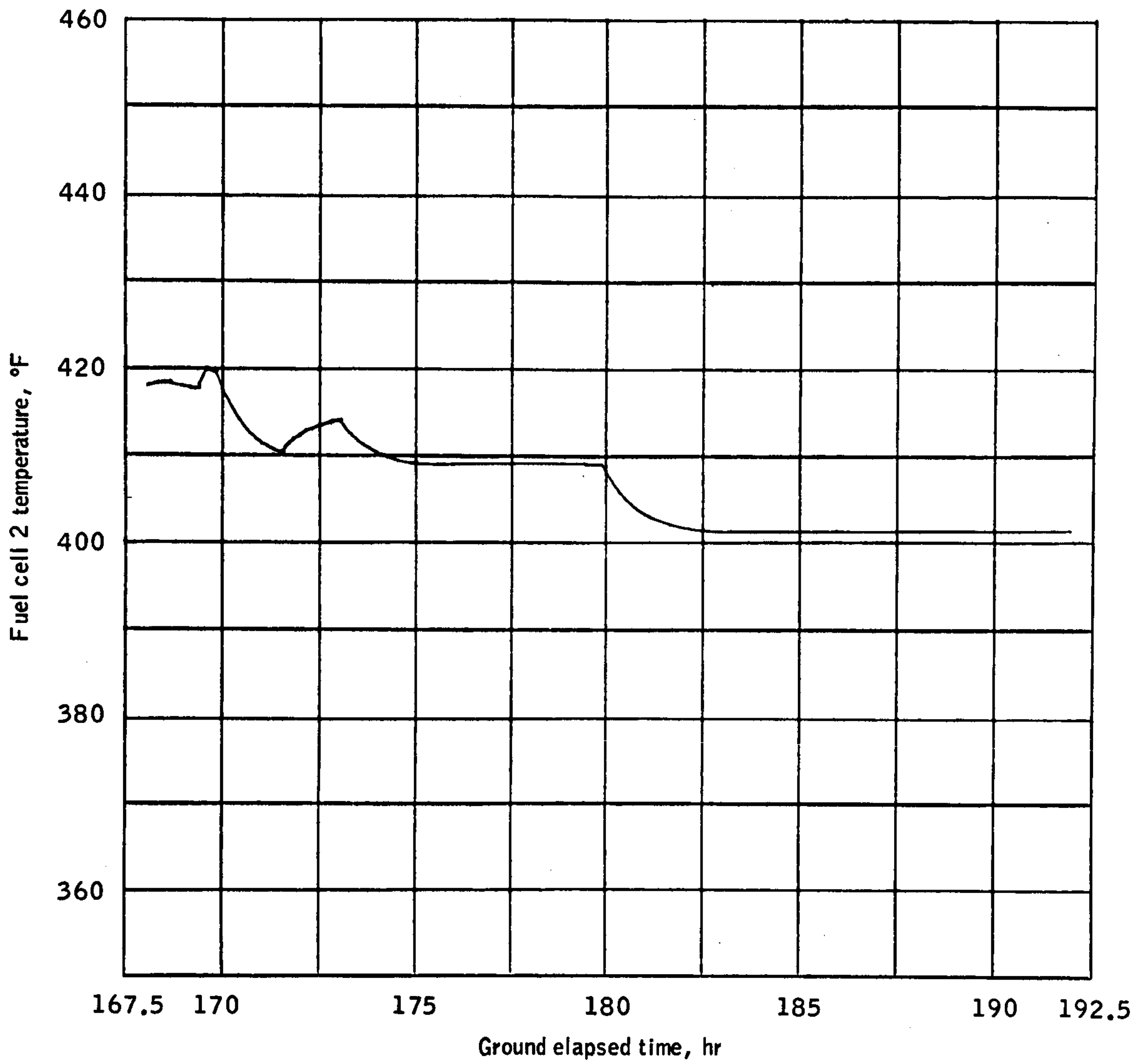
(f) 120 hours to 144 hours, ground elapsed time.

Figure 10.- Continued.



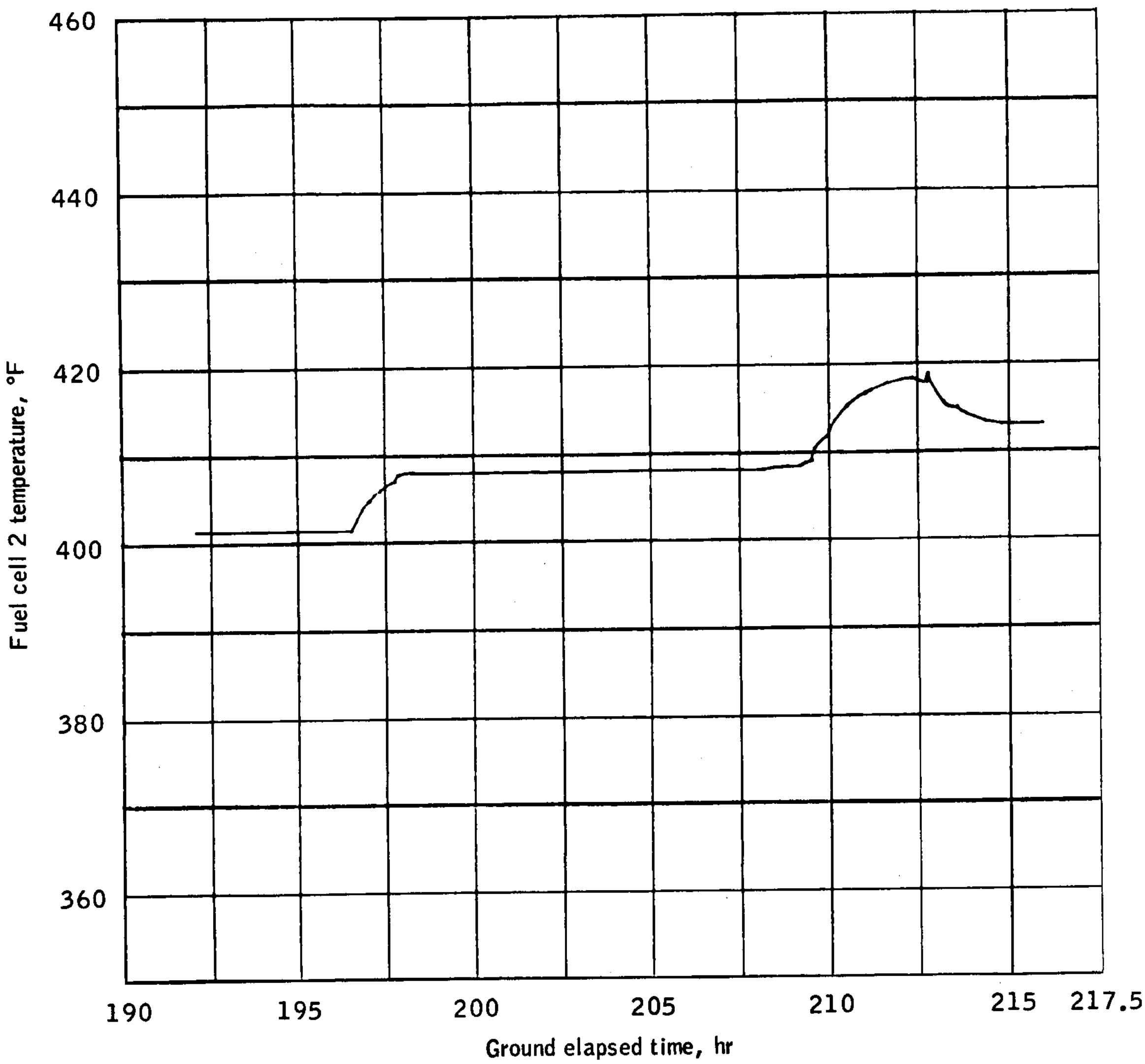
(g) 144 hours to 168 hours, ground elapsed time.

Figure 10.- Continued.



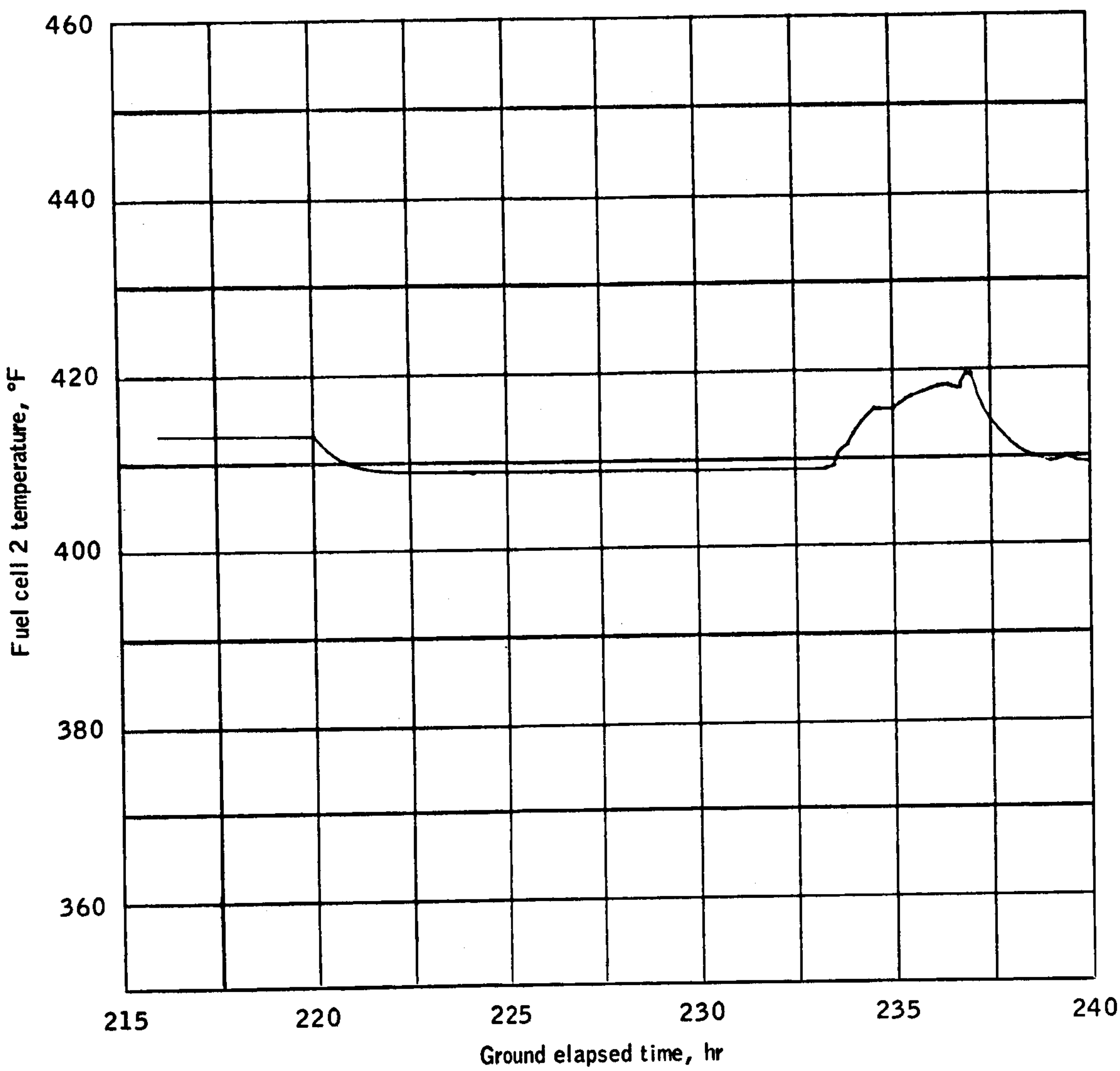
(h) 168 hours to 192 hours, ground elapsed time.

Figure 10.- Continued.



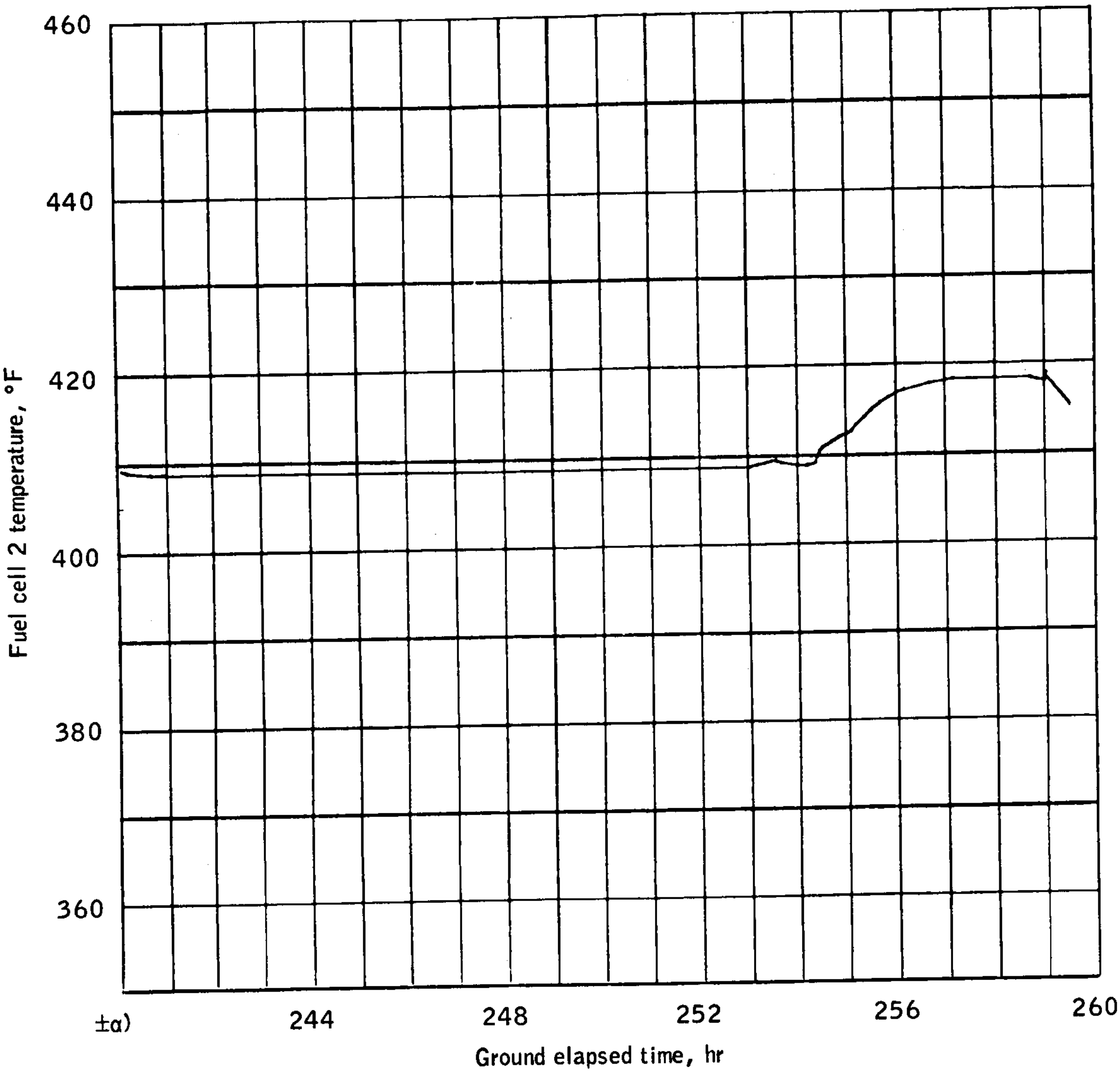
(i) 192 hours to 216 hours, ground elapsed time.

Figure 10.- Continued.



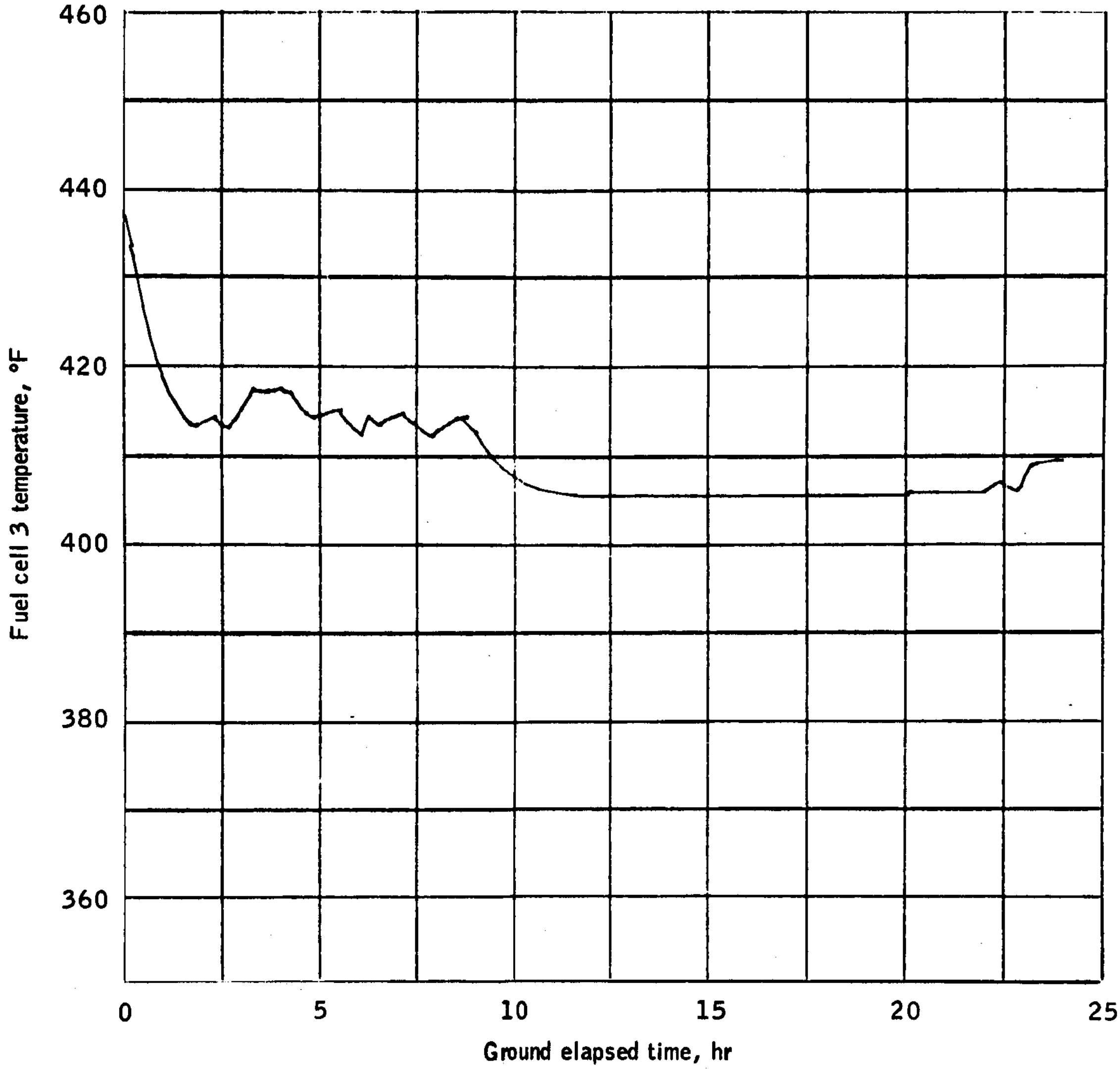
(j) 216 hours to 240 hours, ground elapsed time.

Figure 10.- Continued.



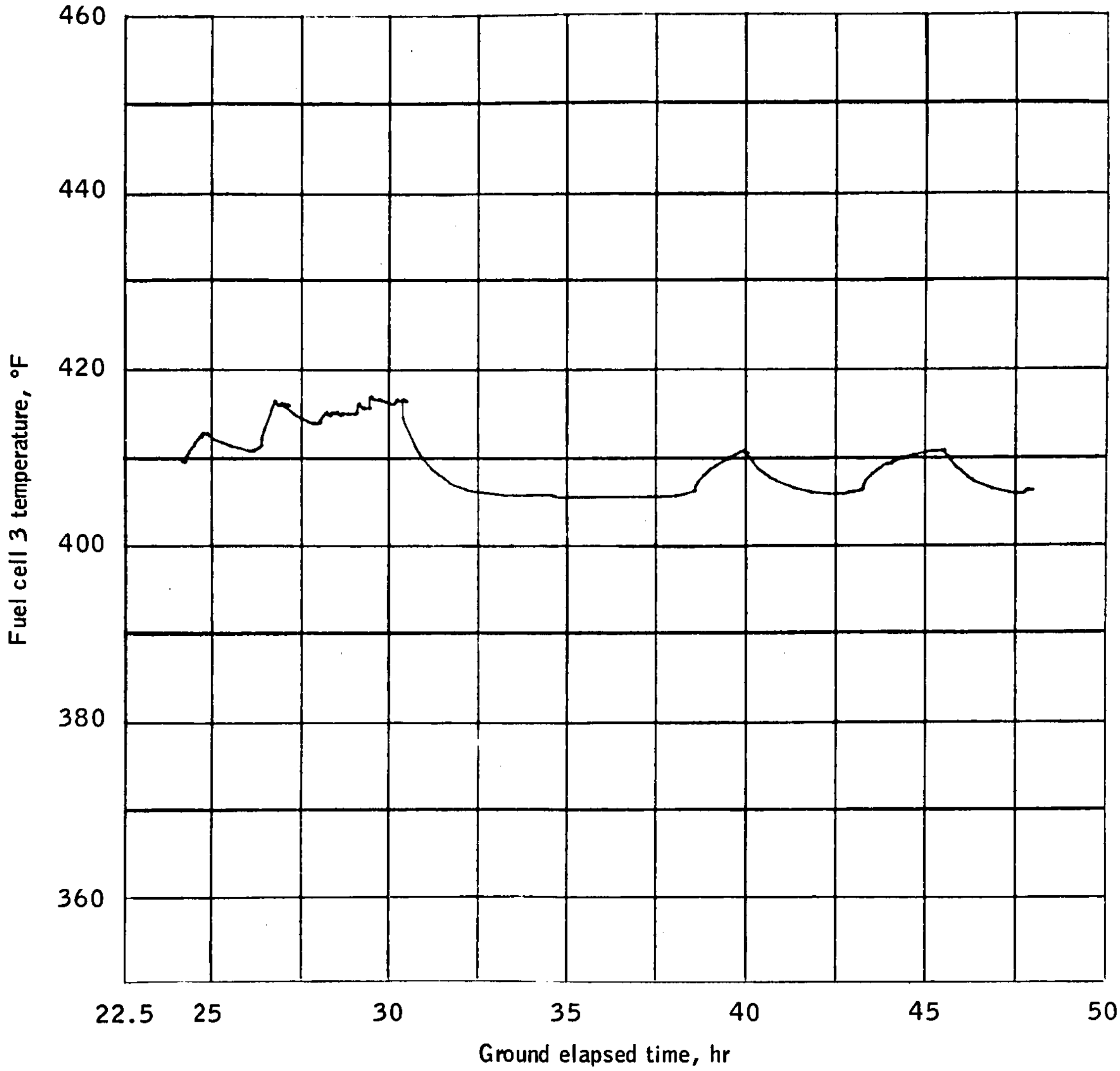
(k) 240 hours to 260 hours, ground elapsed time.

Figure 10.- Concluded.



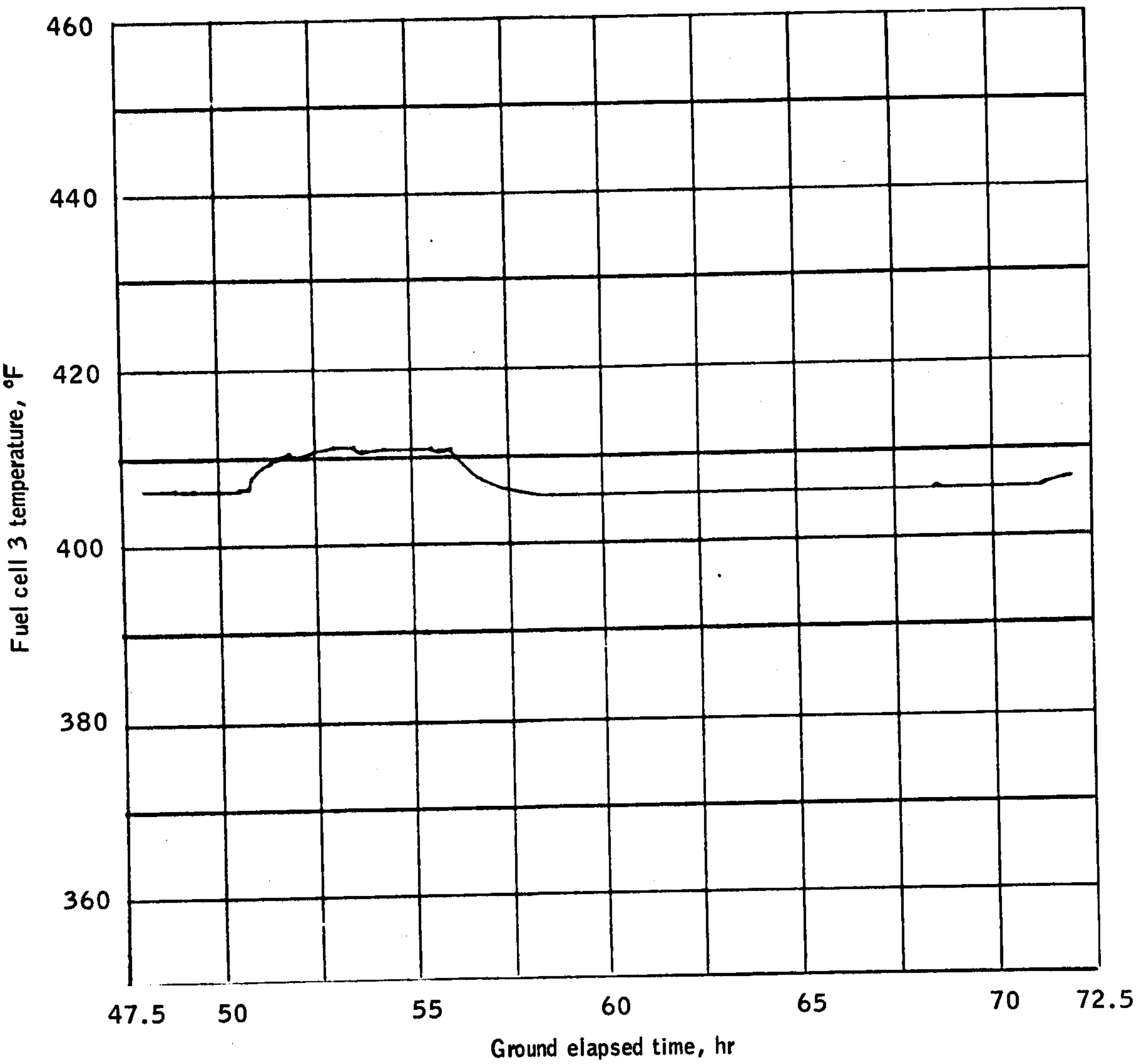
(a) Lift-off to 24 hours, ground elapsed time.

Figure 11.- Time history of fuel cell 3 temperature.



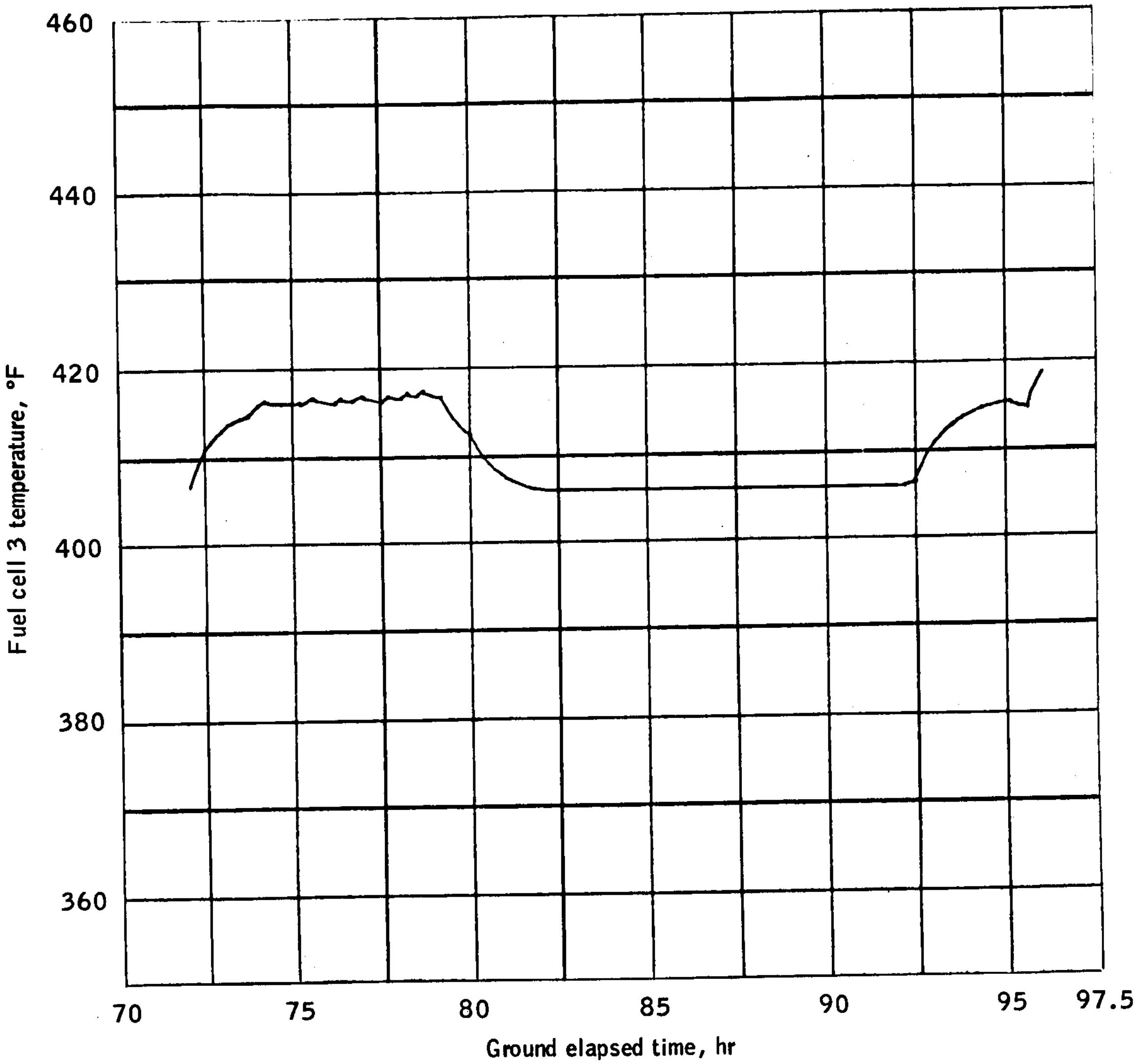
(b) 24 hours to 48 hours, ground elapsed time.

Figure 11.- Continued.



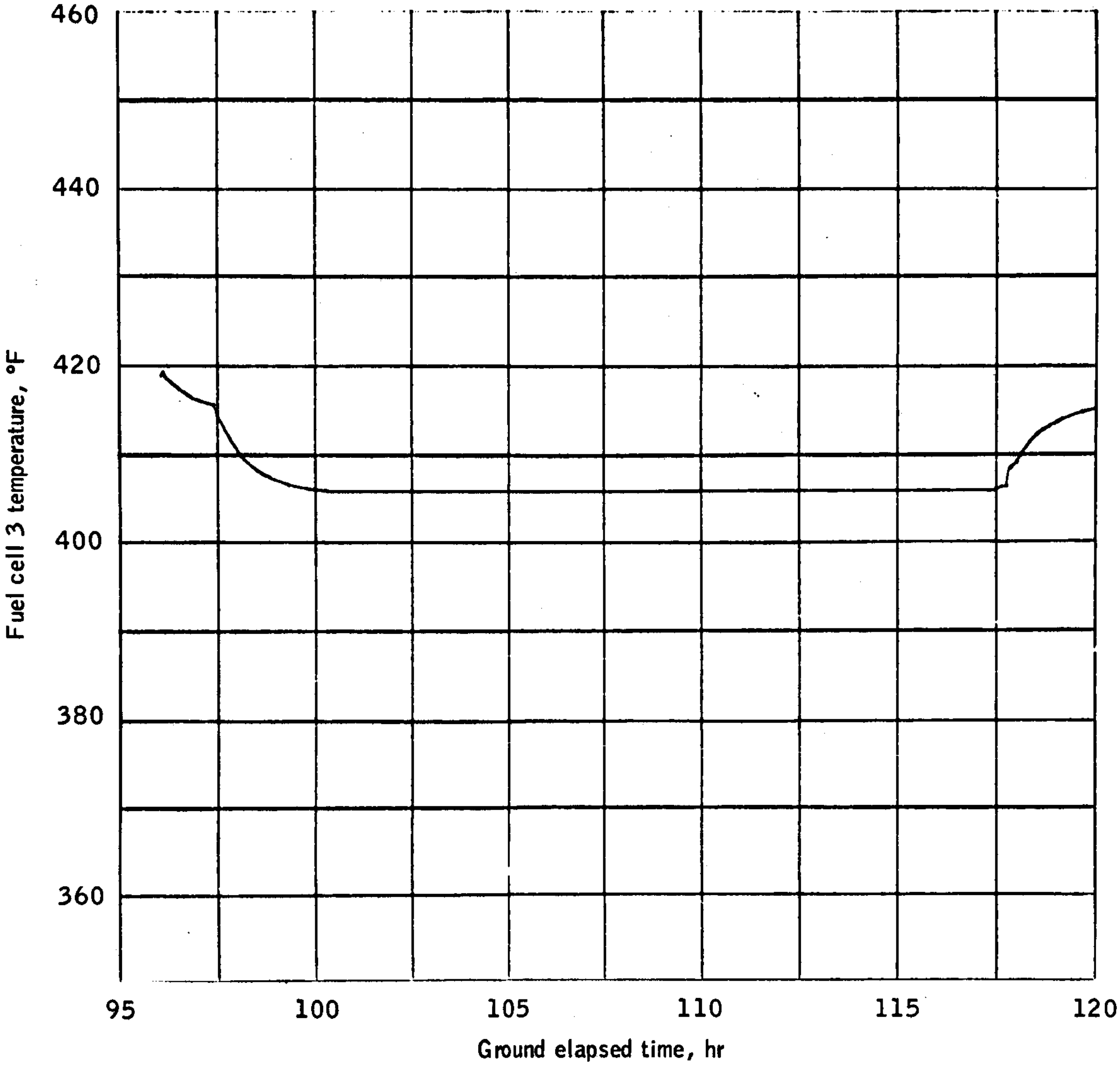
(c) 48 hours to 72 hours, ground elapsed time.

Figure 11.- Continued.



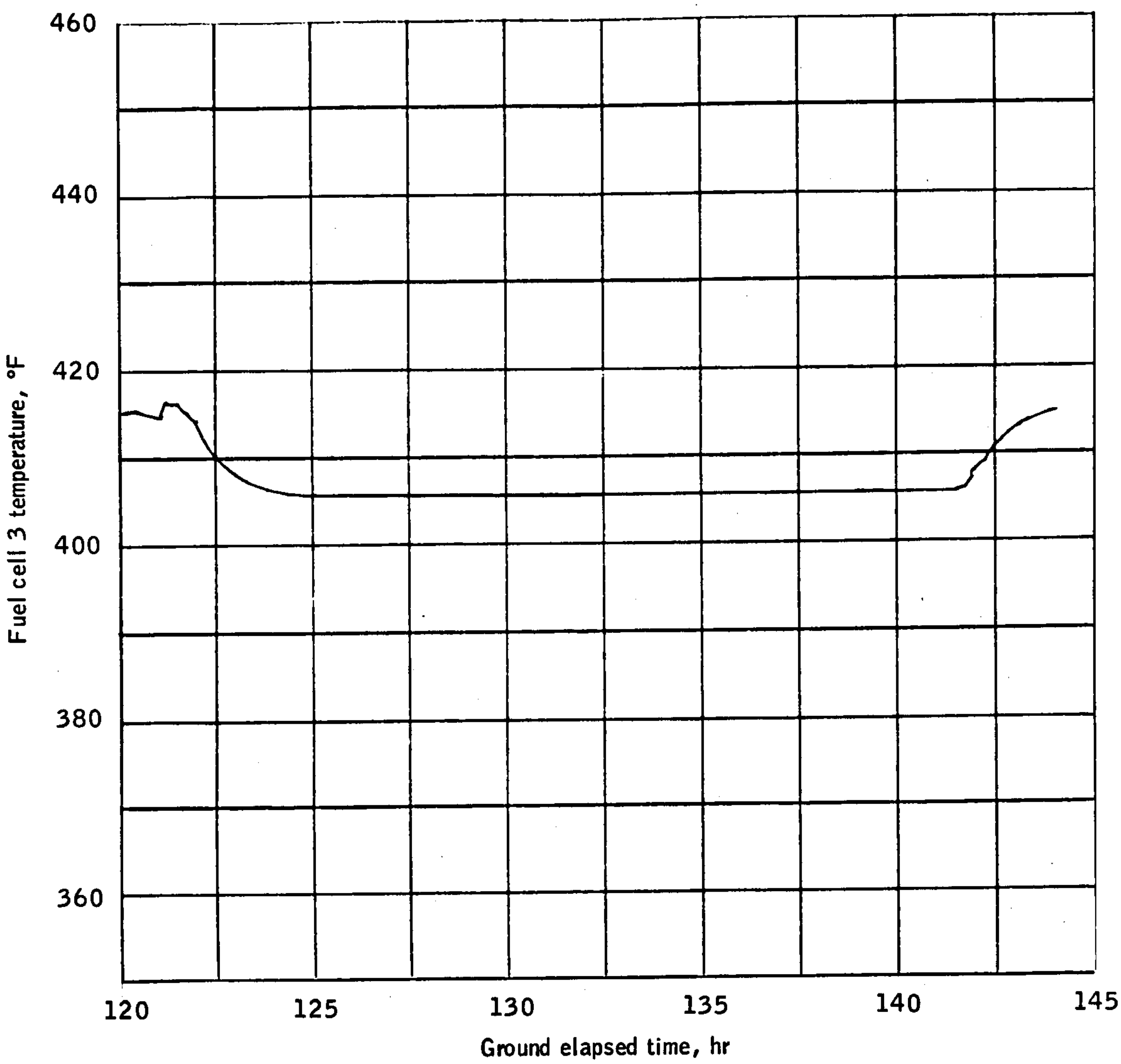
(d) 72 hours to 96 hours, ground elapsed time.

Figure 11.- Continued.



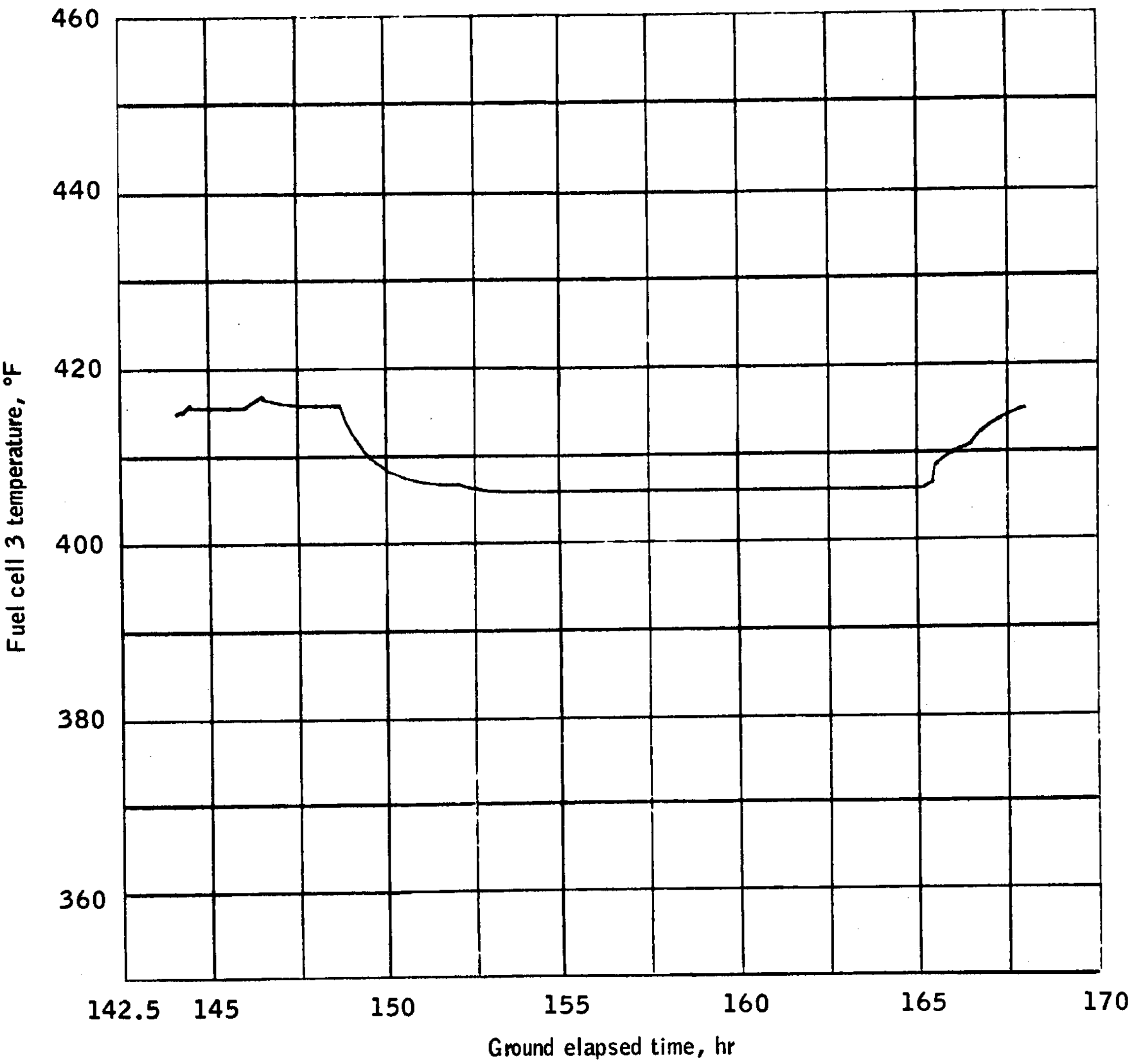
(e) 96 hours to 120 hours, ground elapsed time.

Figure 11.- Continued.



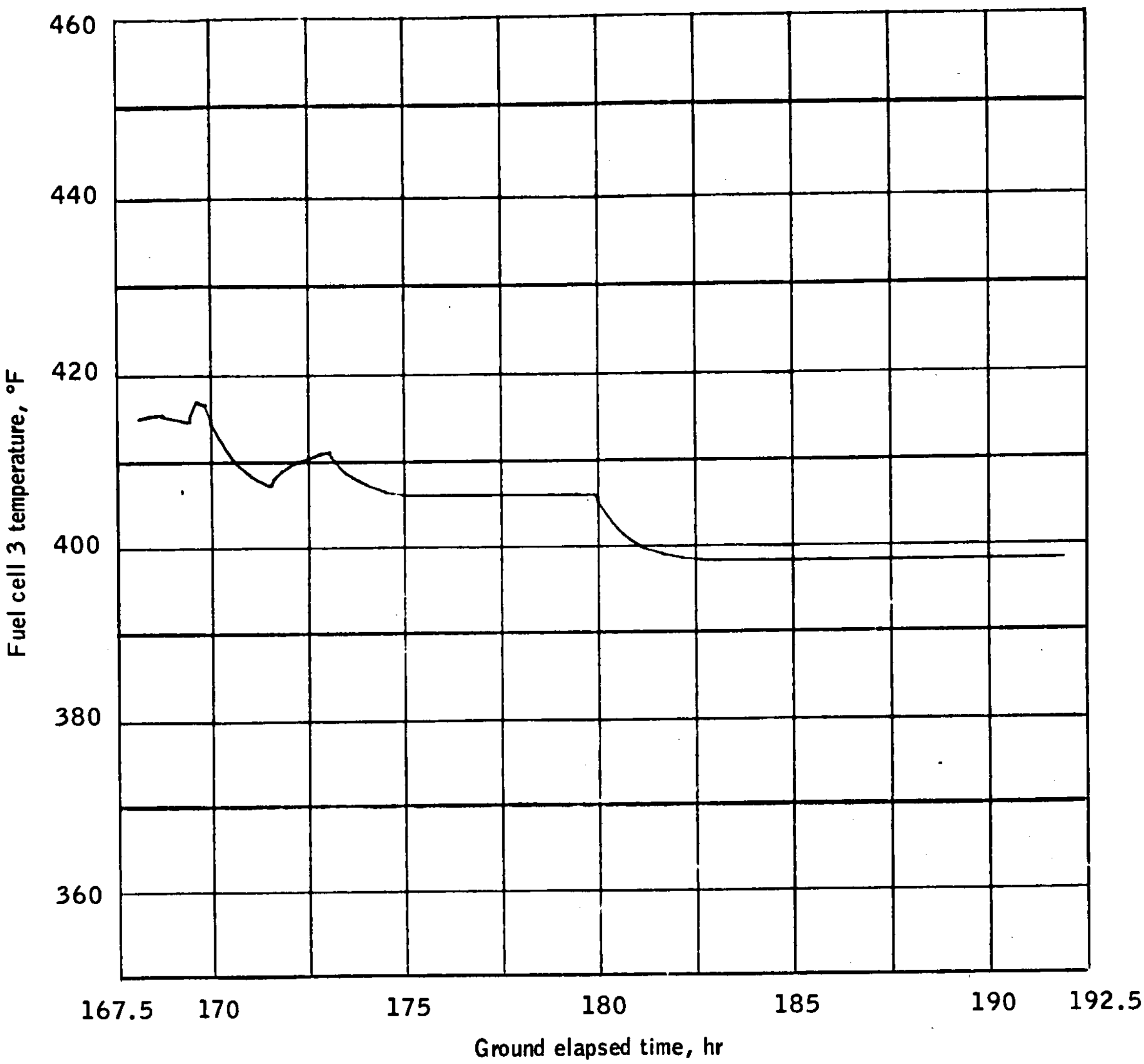
(f) 120 hours to 144 hours, ground elapsed time.

Figure 11.- Continued.



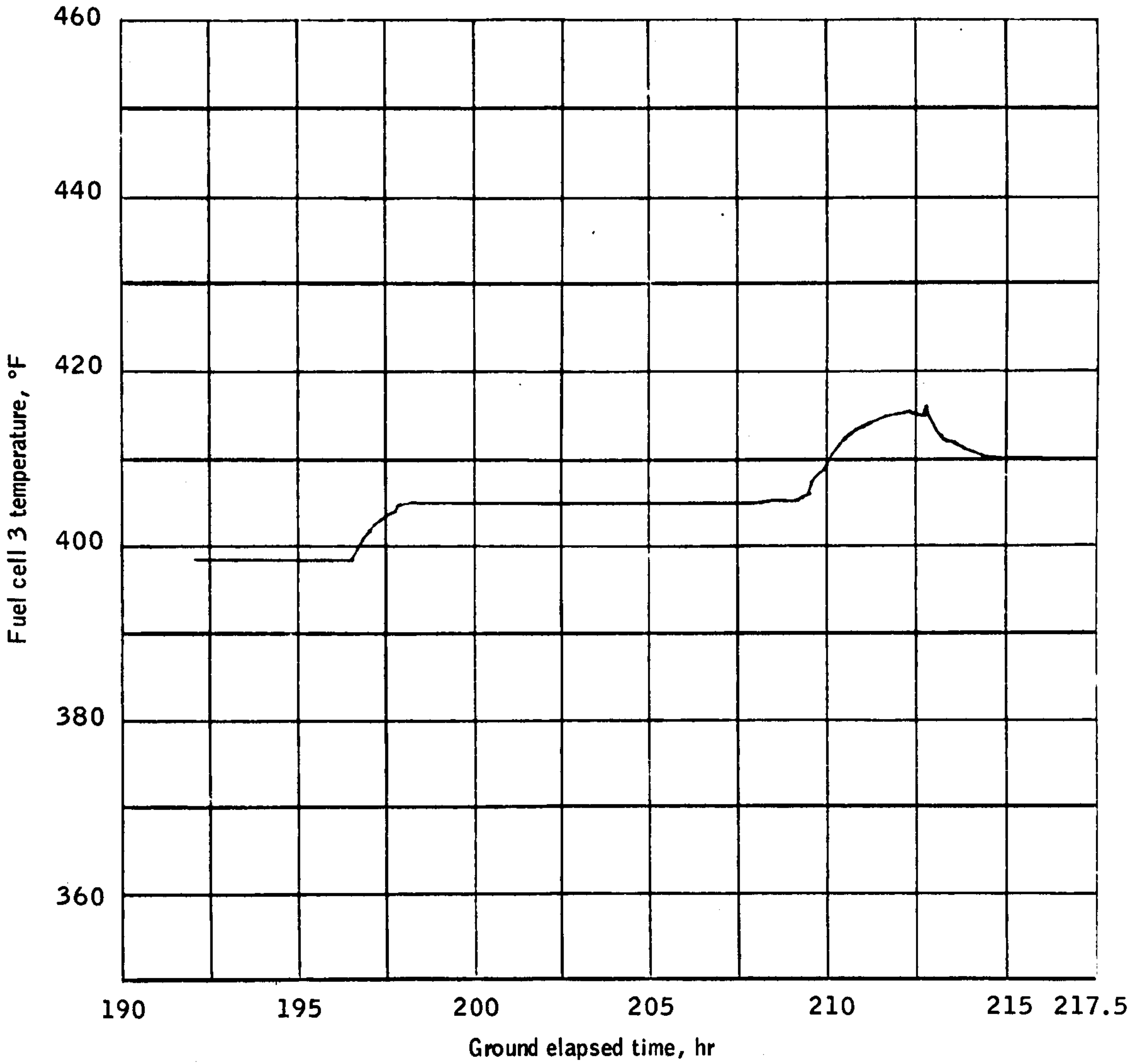
(g) 144 hours to 168 hours, ground elapsed time.

Figure 11.- Continued.



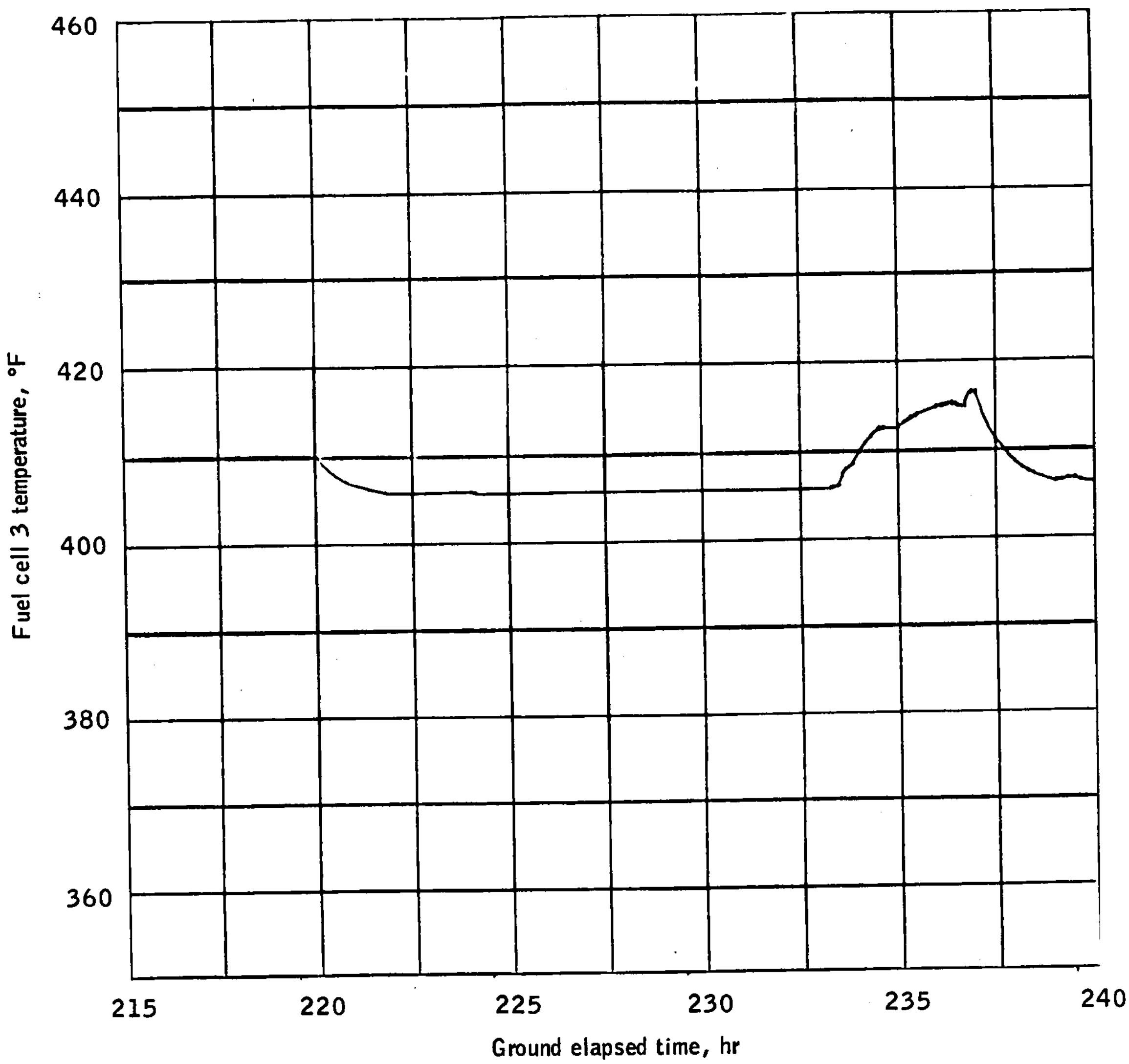
(h) 168 hours to 192 hours, ground elapsed time.

Figure 11.- Continued.



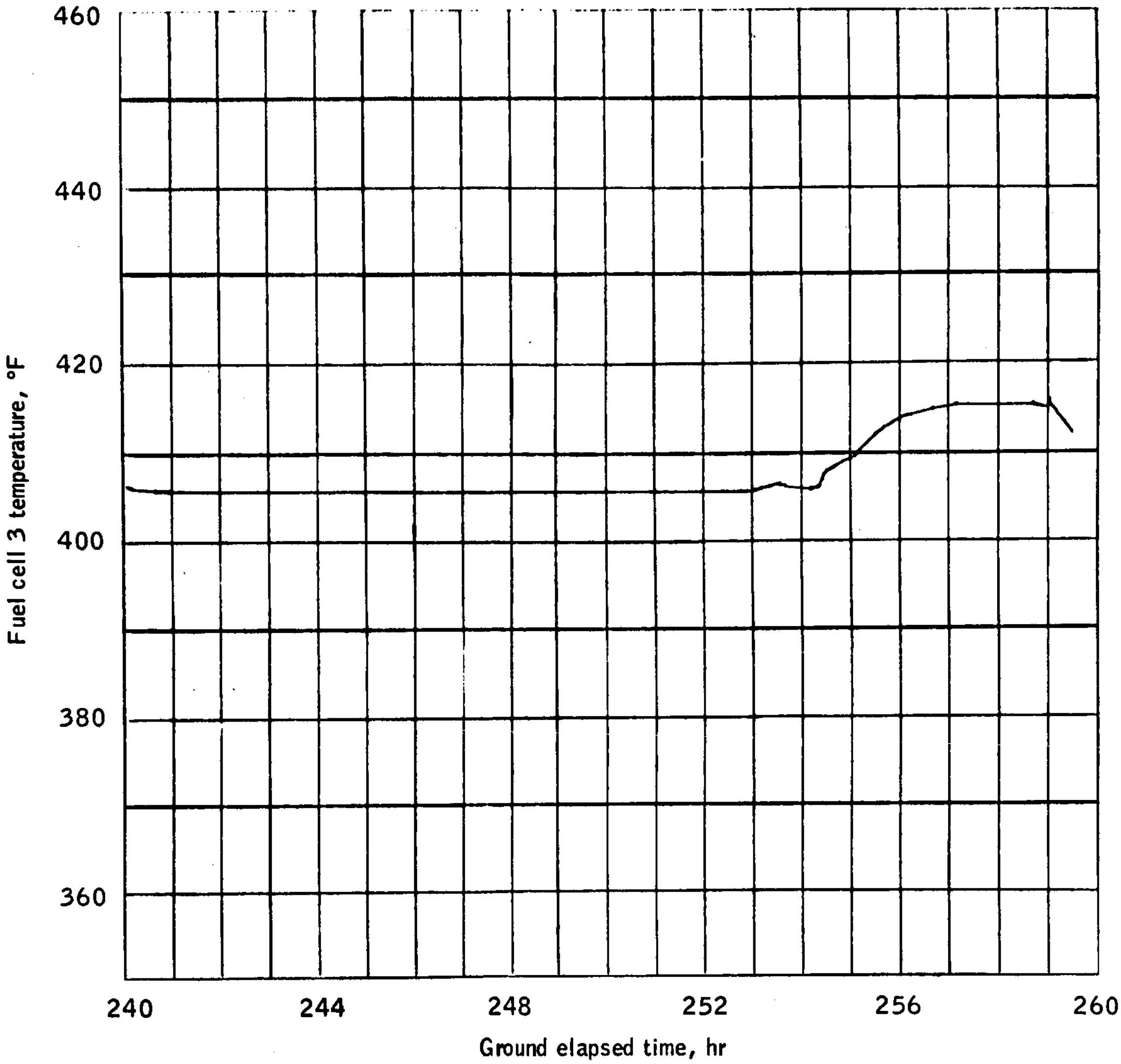
(i) 192 hours to 216 hours, ground elapsed time.

Figure 11.- Continued.



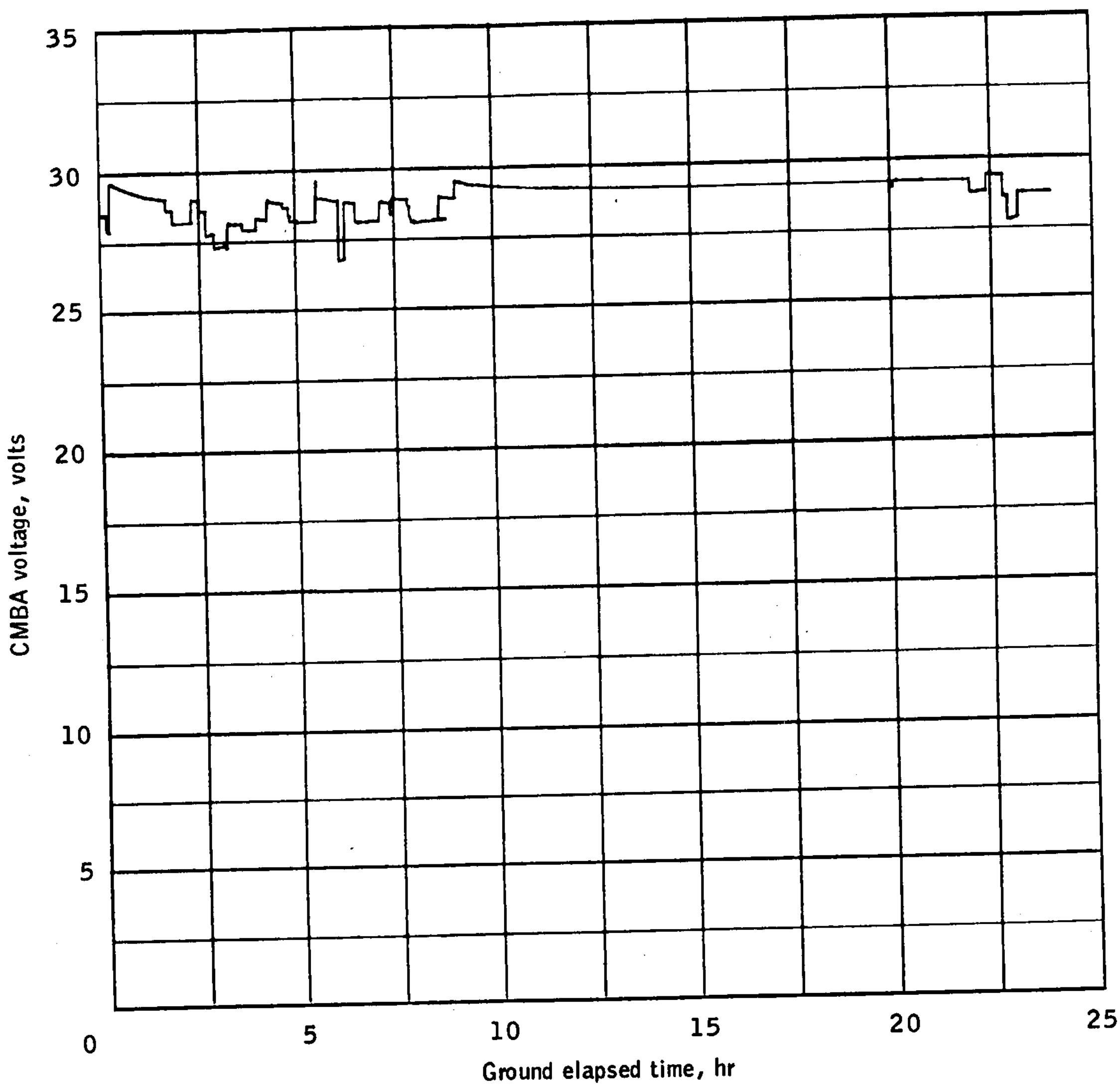
(j) 216 hours to 240 hours, ground elapsed time.

Figure 11.- Continued.



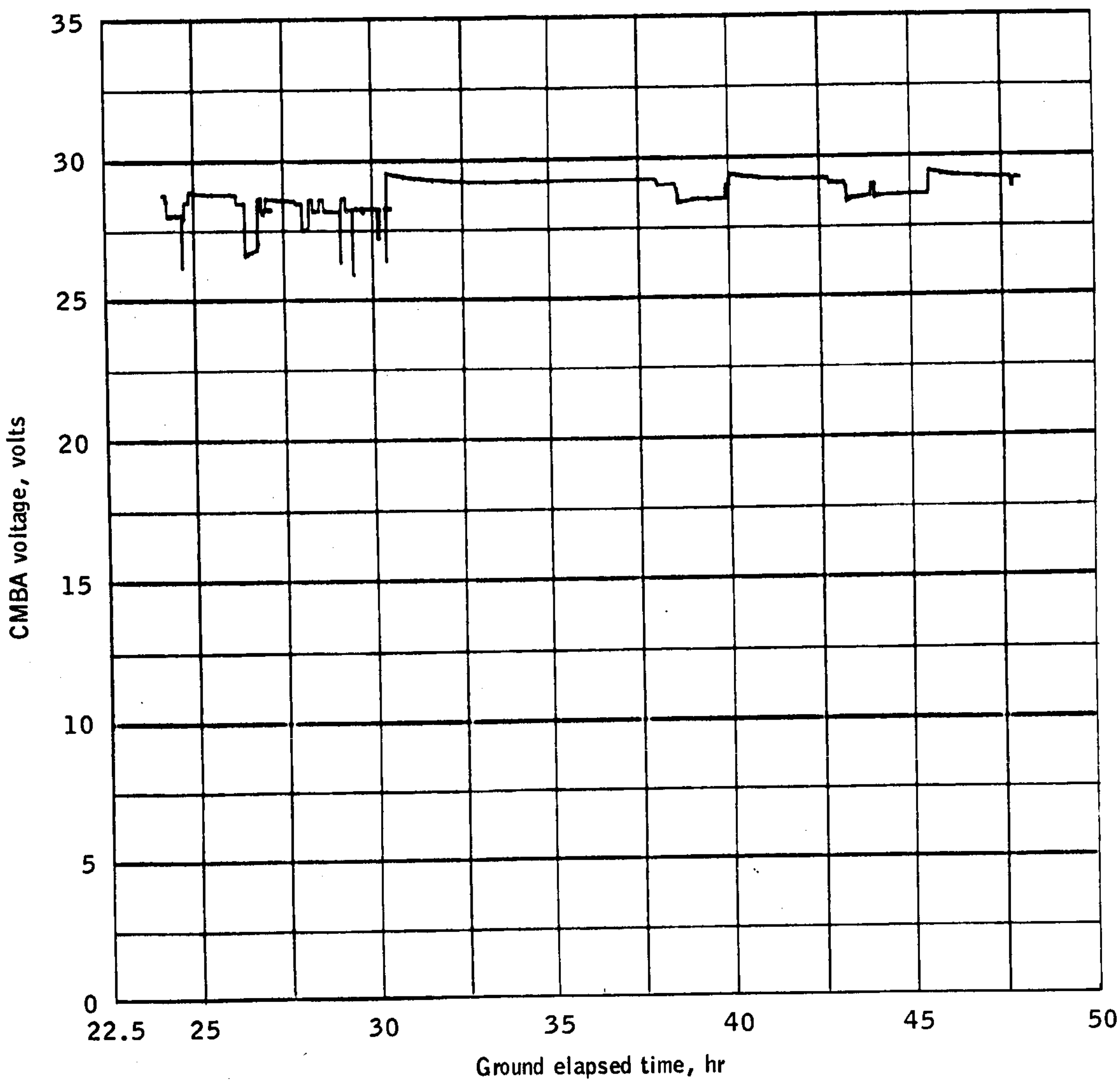
(k) 240 hours to 260 hours, ground elapsed time.

Figure 11.- Concluded.



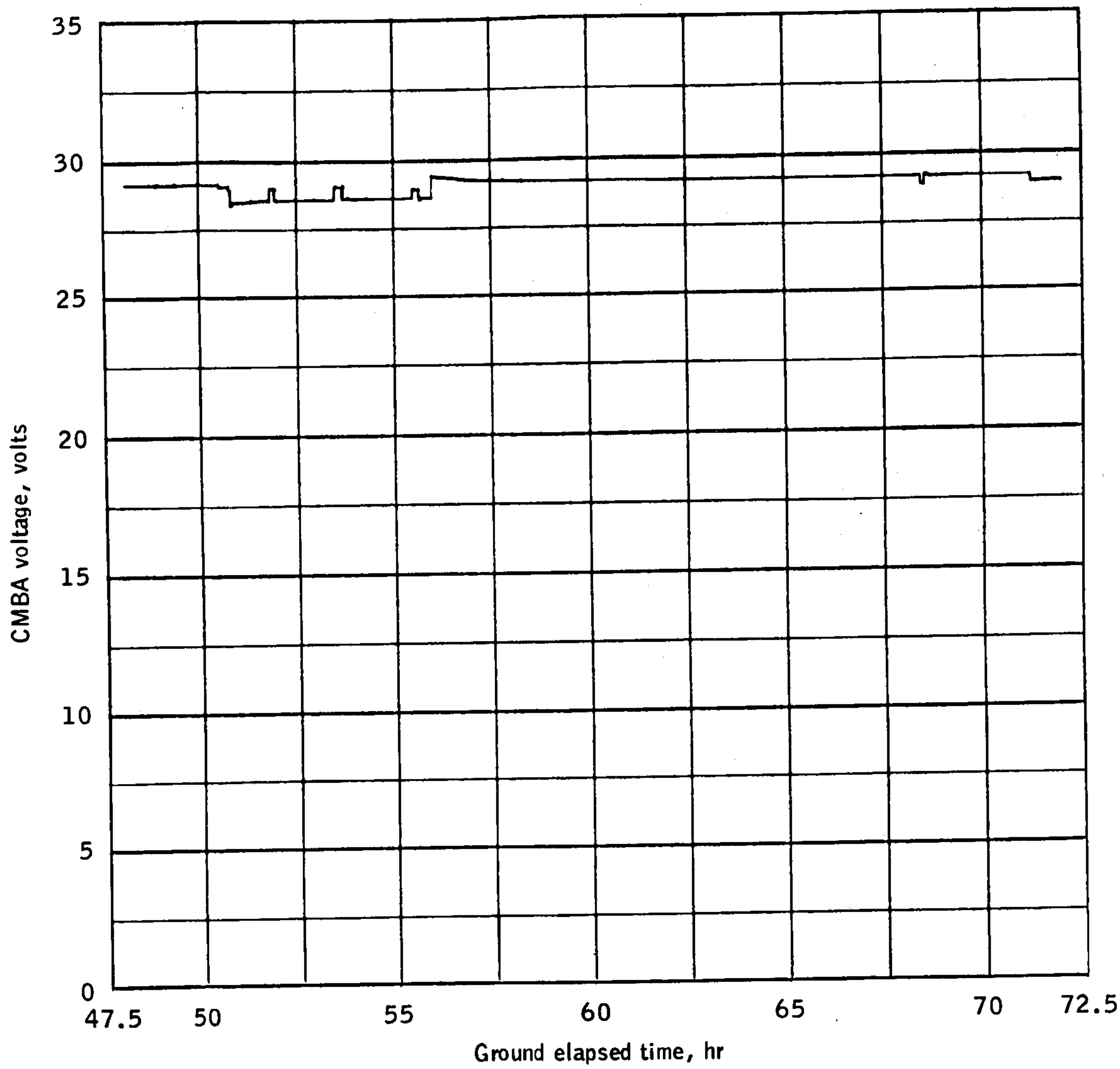
(a) Lift-off to 24 hours, ground elapsed time.

Figure 12.- Time history of command module bus A voltage.



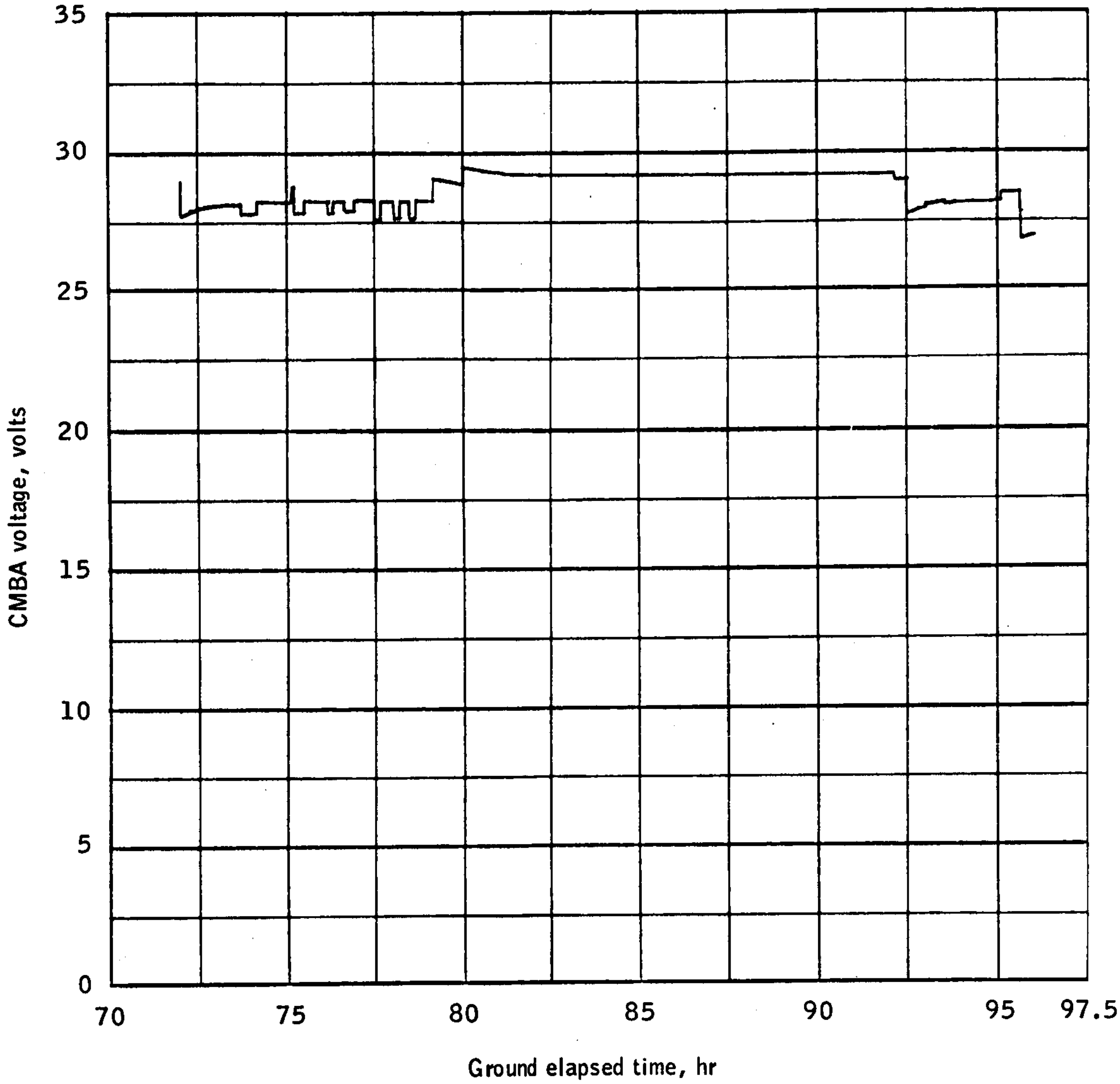
(b) 24 hours to 48 hours, ground elapsed time.

Figure 12.- Continued.



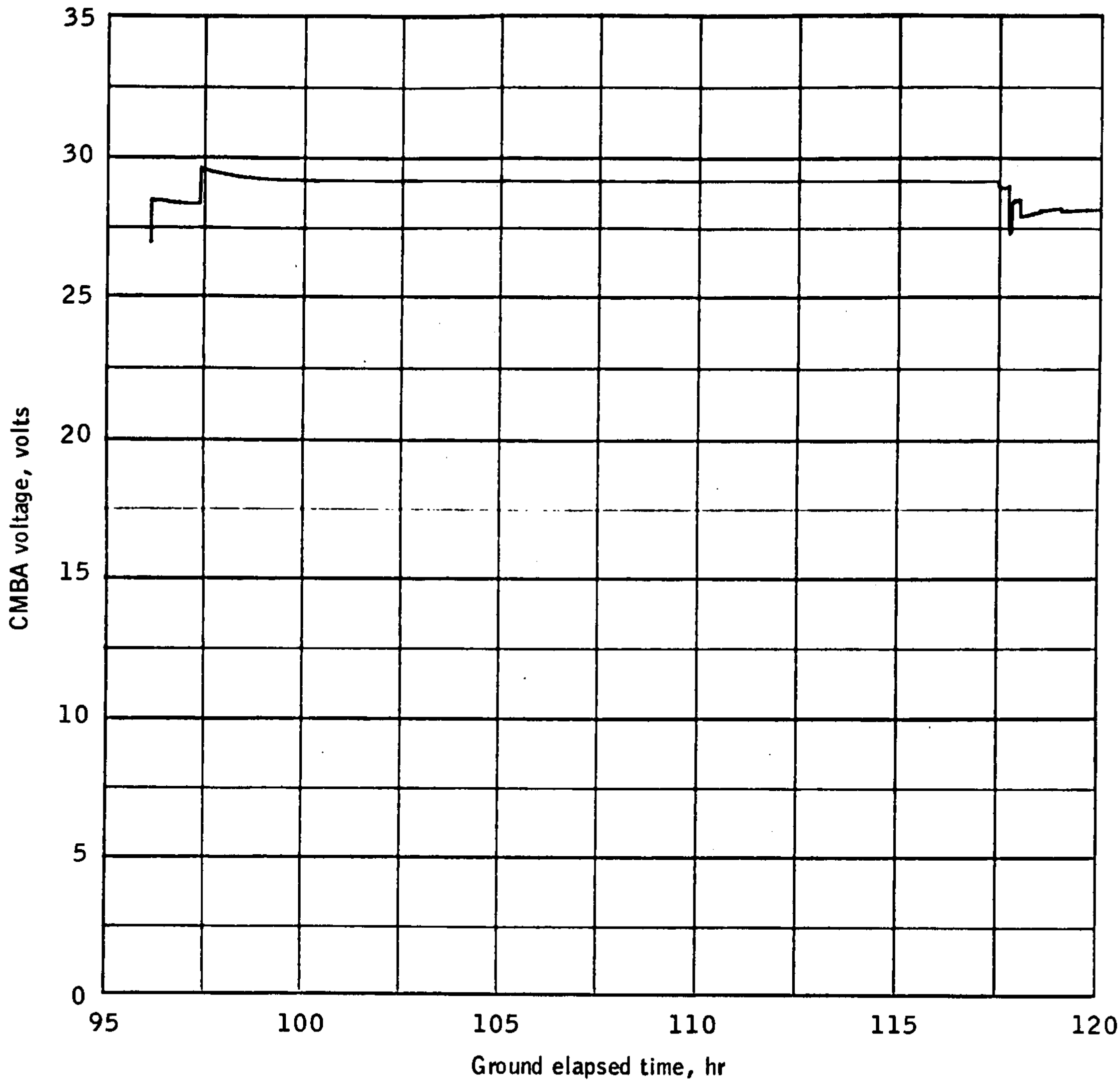
(c) 48 hours to 72 hours, ground elapsed time.

Figure 12.- Continued.



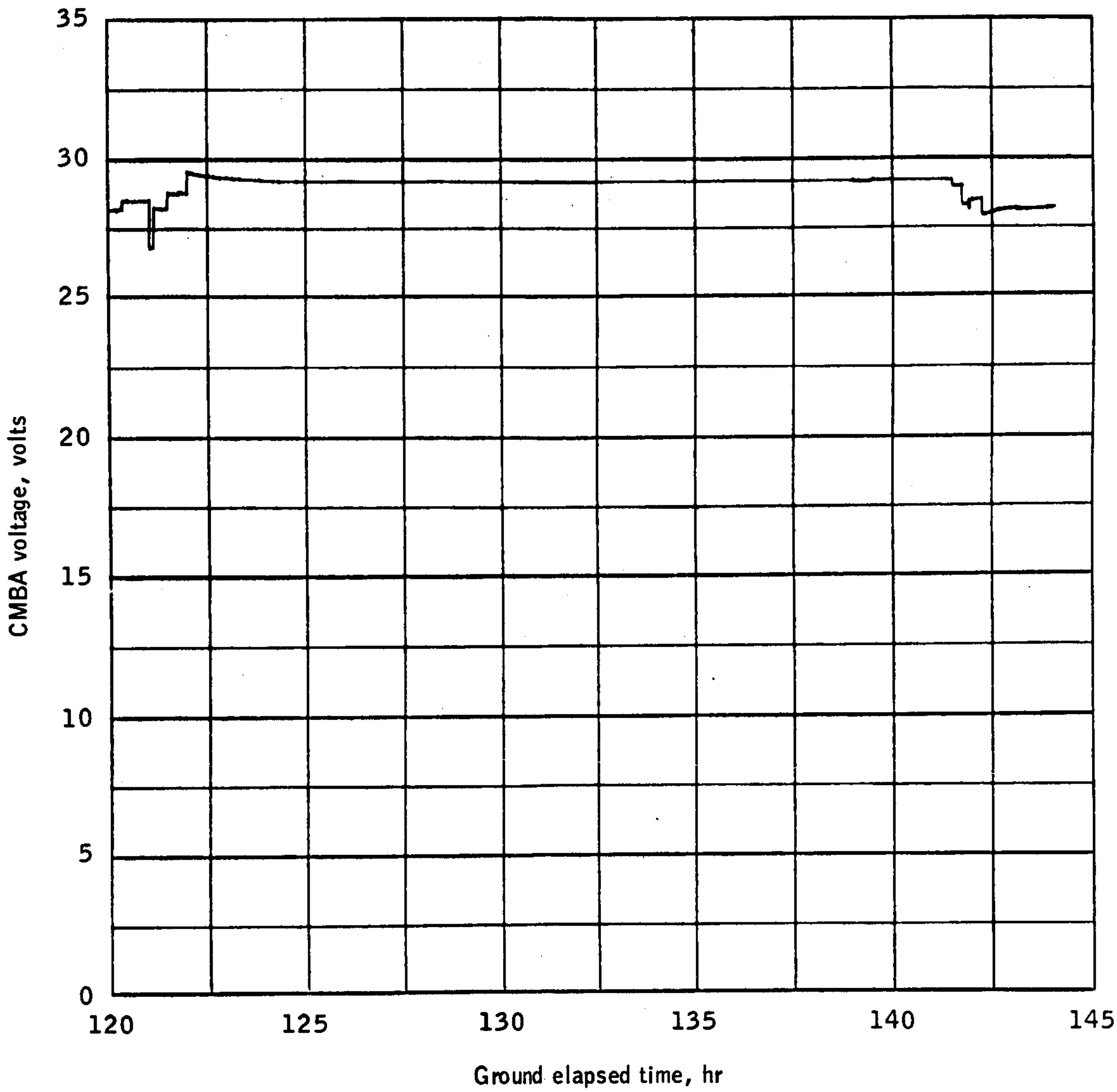
(d) 72 hours to 96 hours, ground elapsed time.

Figure 12.- Continued.



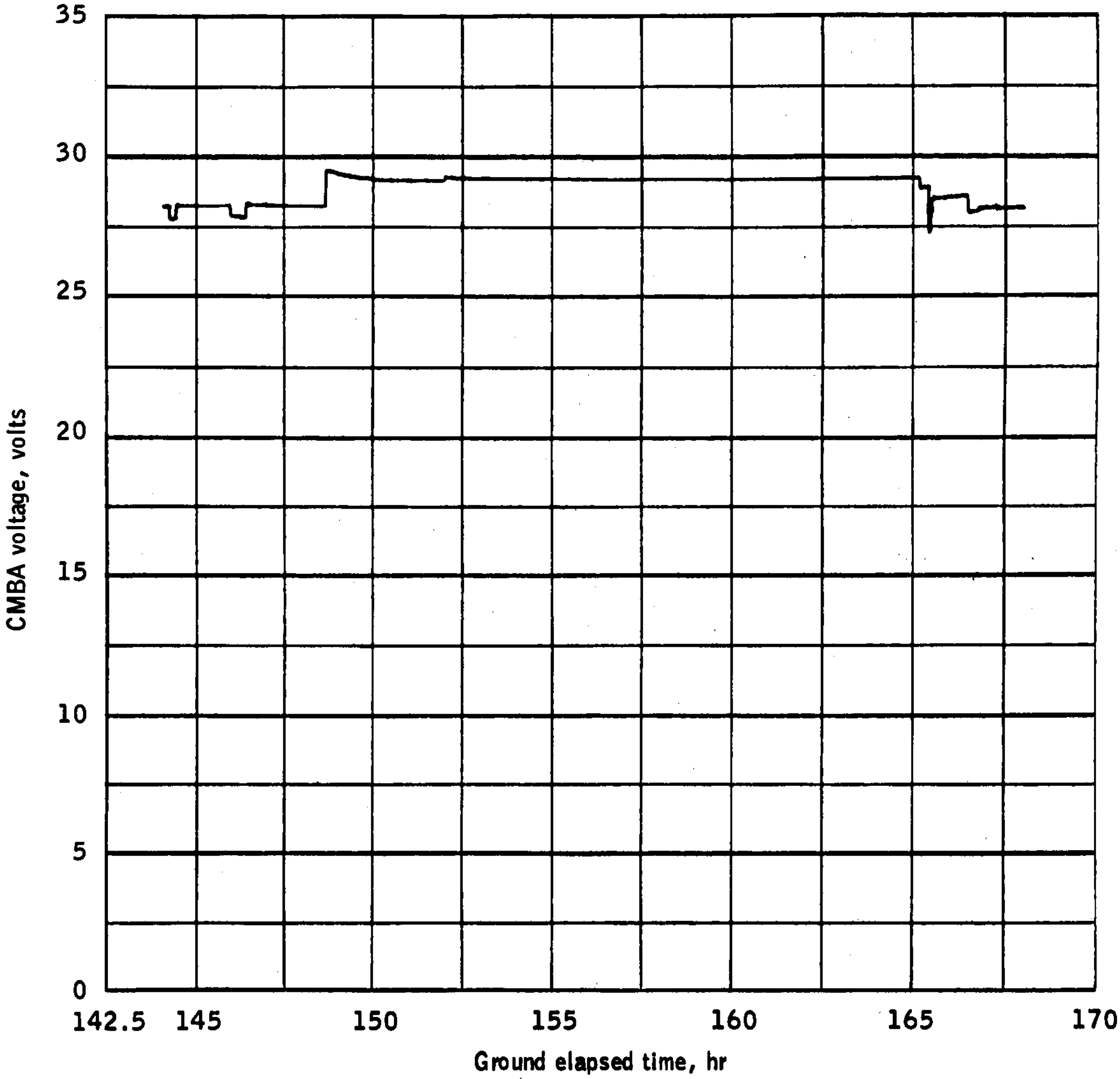
(e) 96 hours to 120 hours, ground elapsed time.

Figure 12.- Continued.



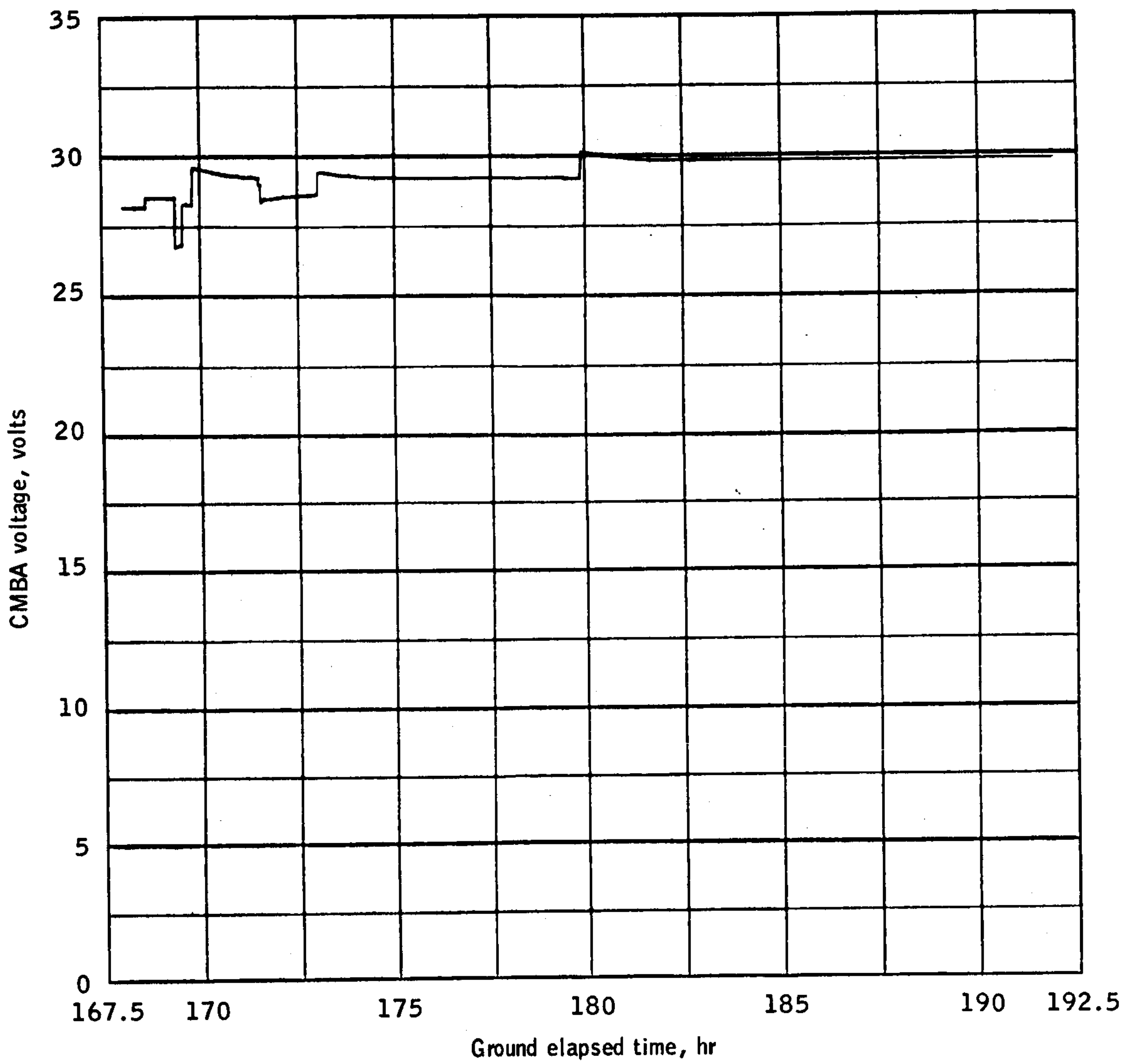
(f) 120 hours to 144 hours, ground elapsed time.

Figure 12.- Continued.



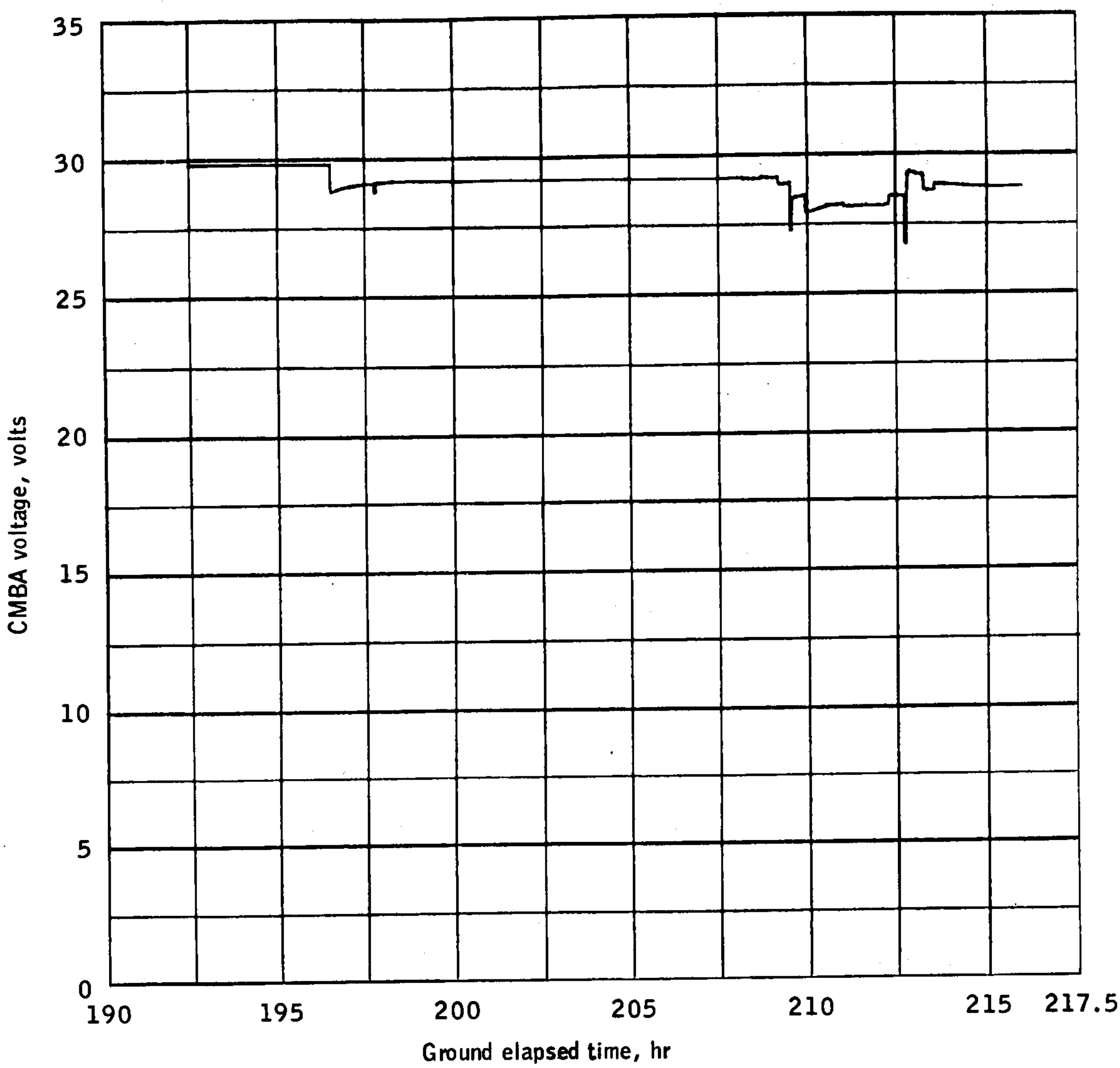
(g) 144 hours to 168 hours, ground elapsed time.

Figure 12.- Continued.



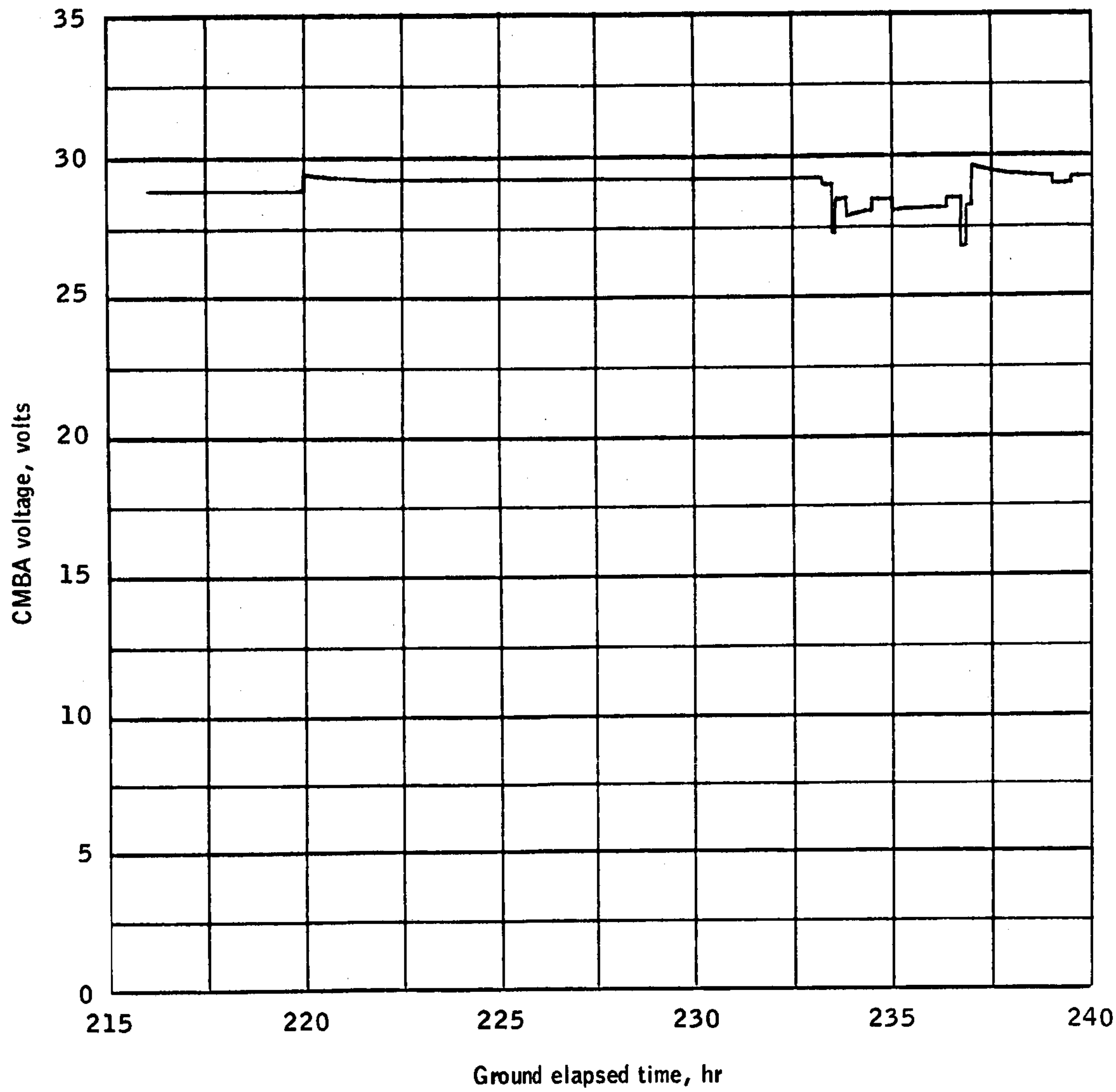
(h) 168 hours to 192 hours, ground elapsed time.

Figure 12.- Continued.



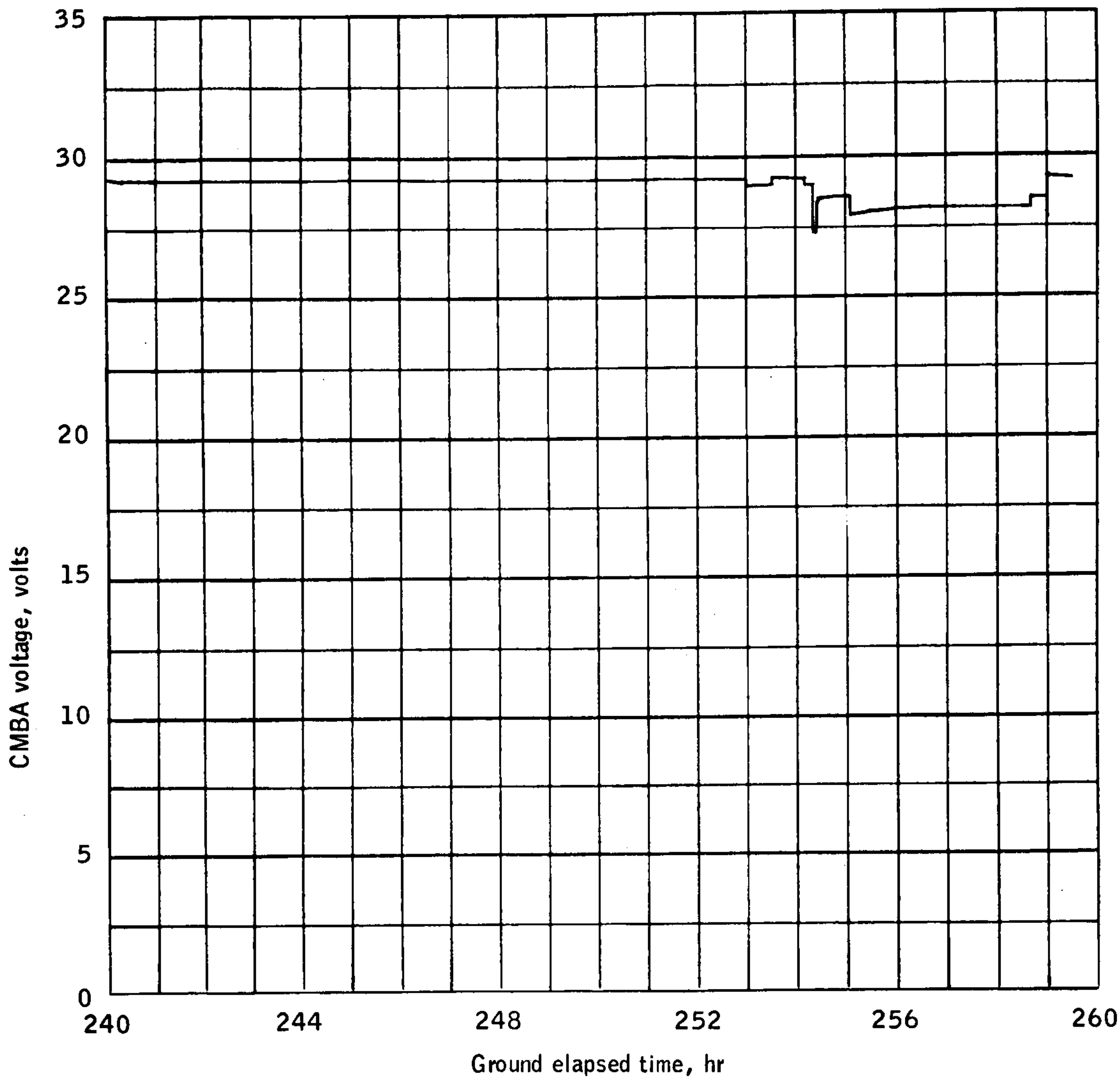
(i) 192 hours to 216 hours, ground elapsed time.

Figure 12.- Continued.



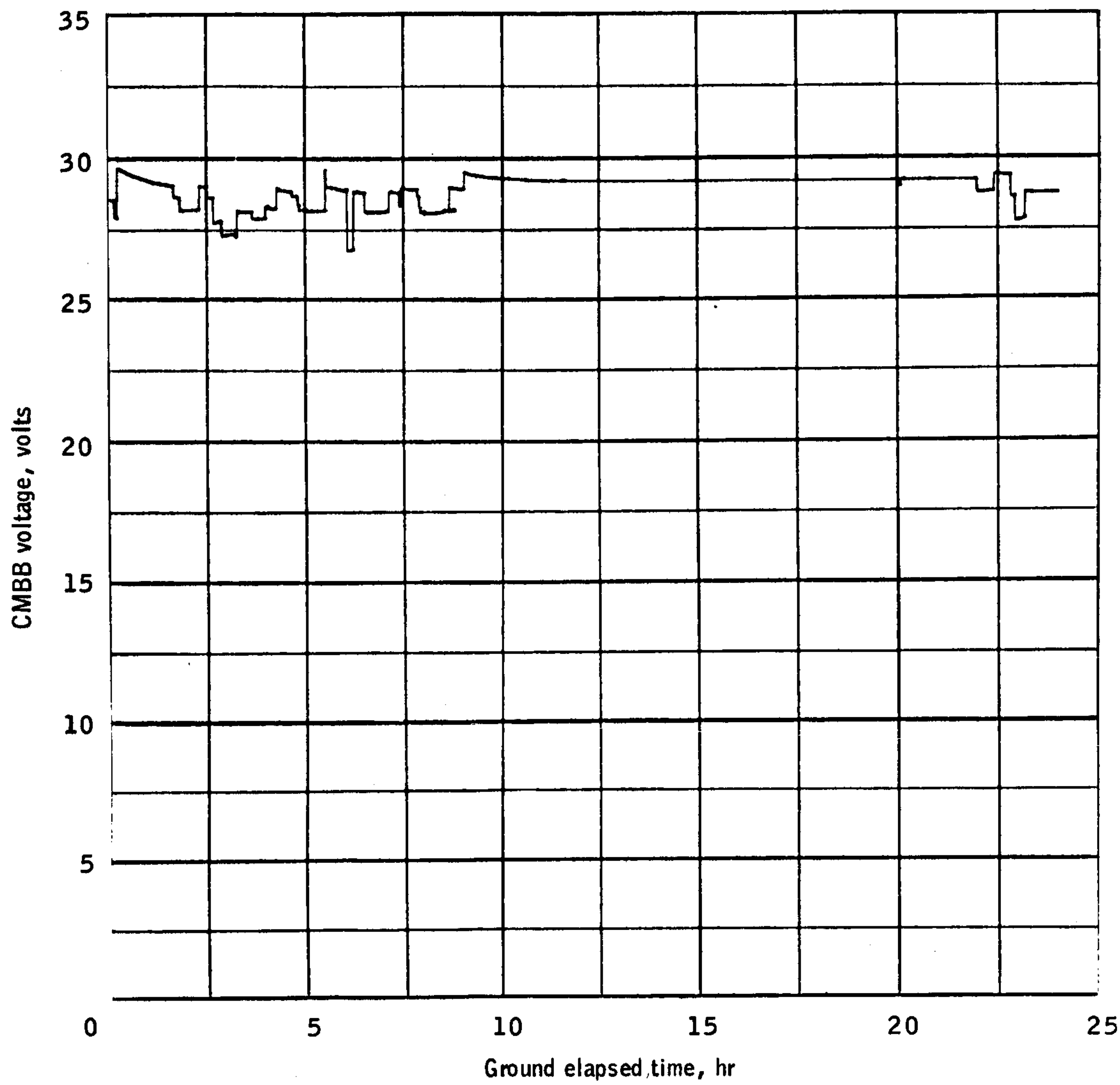
(j) 216 hours to 240 hours, ground elapsed time.

Figure 12.- Continued.



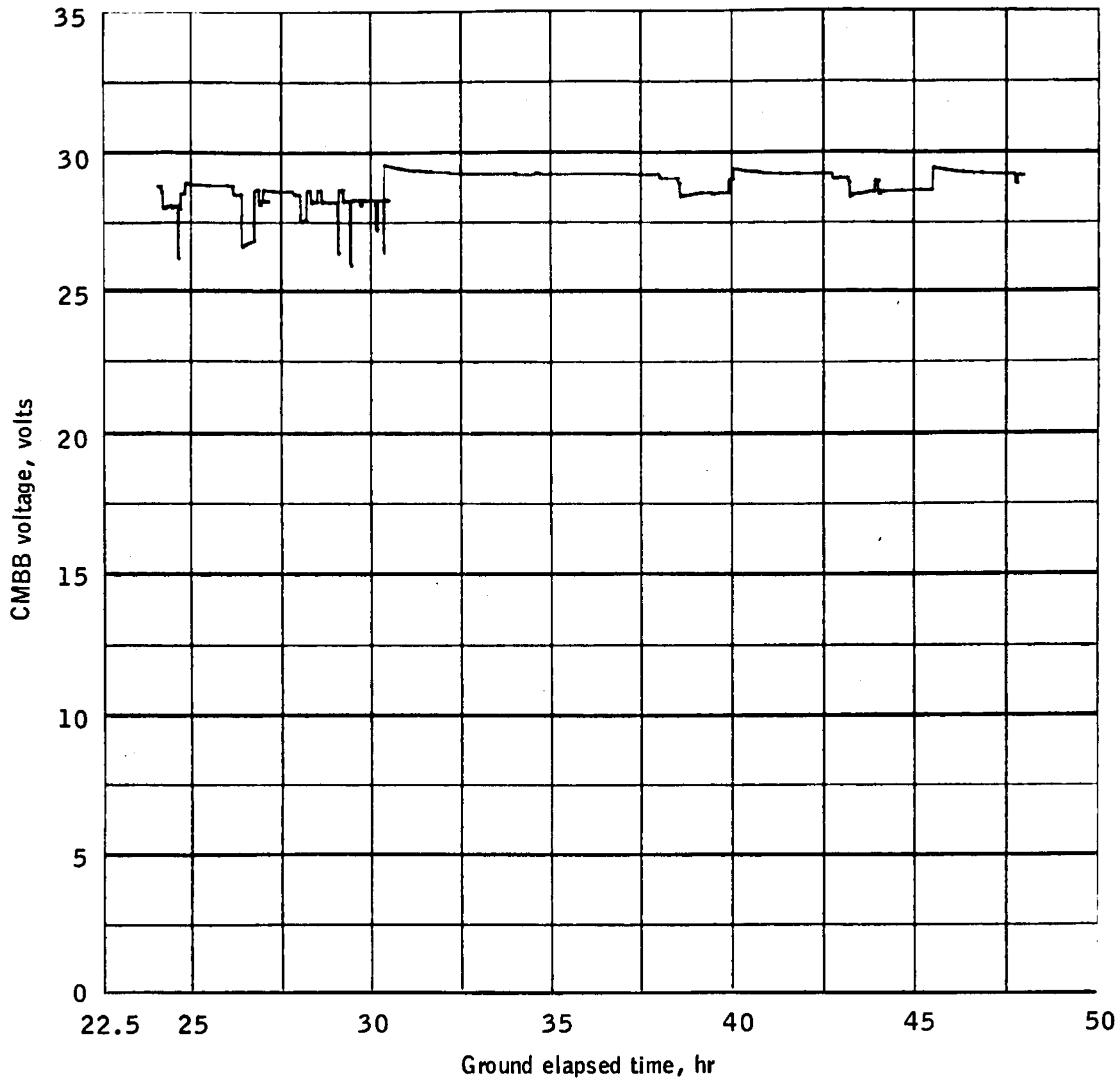
(k) 240 hours to 260 hours, ground elapsed time.

Figure 12.- Concluded.



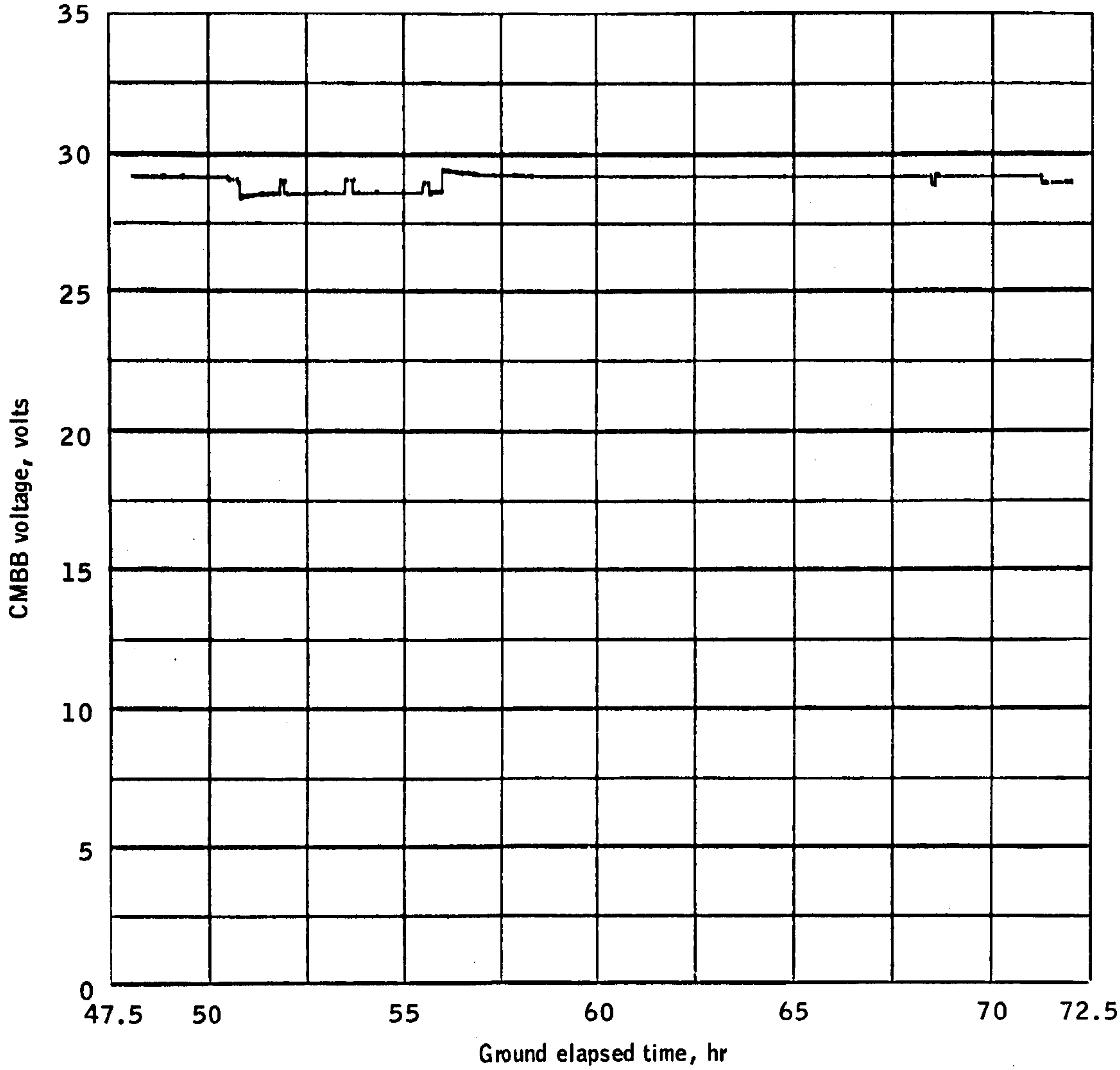
(a) Lift-off to 24 hours, ground elapsed time.

Figure 13.- Time history of command module bus B voltage.



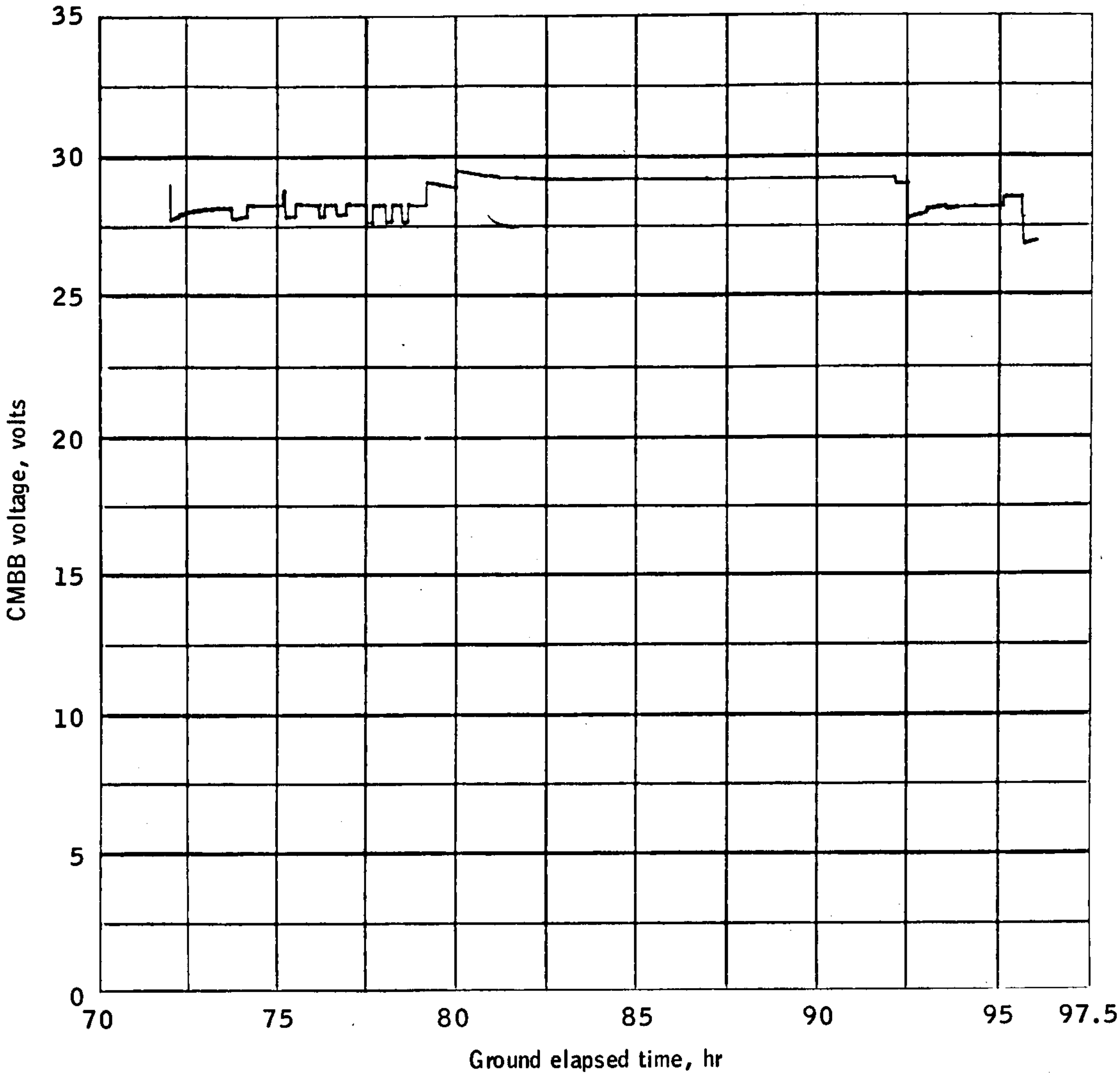
(b) 24 hours to 48 hours, ground elapsed time.

Figure 13.- Continued.



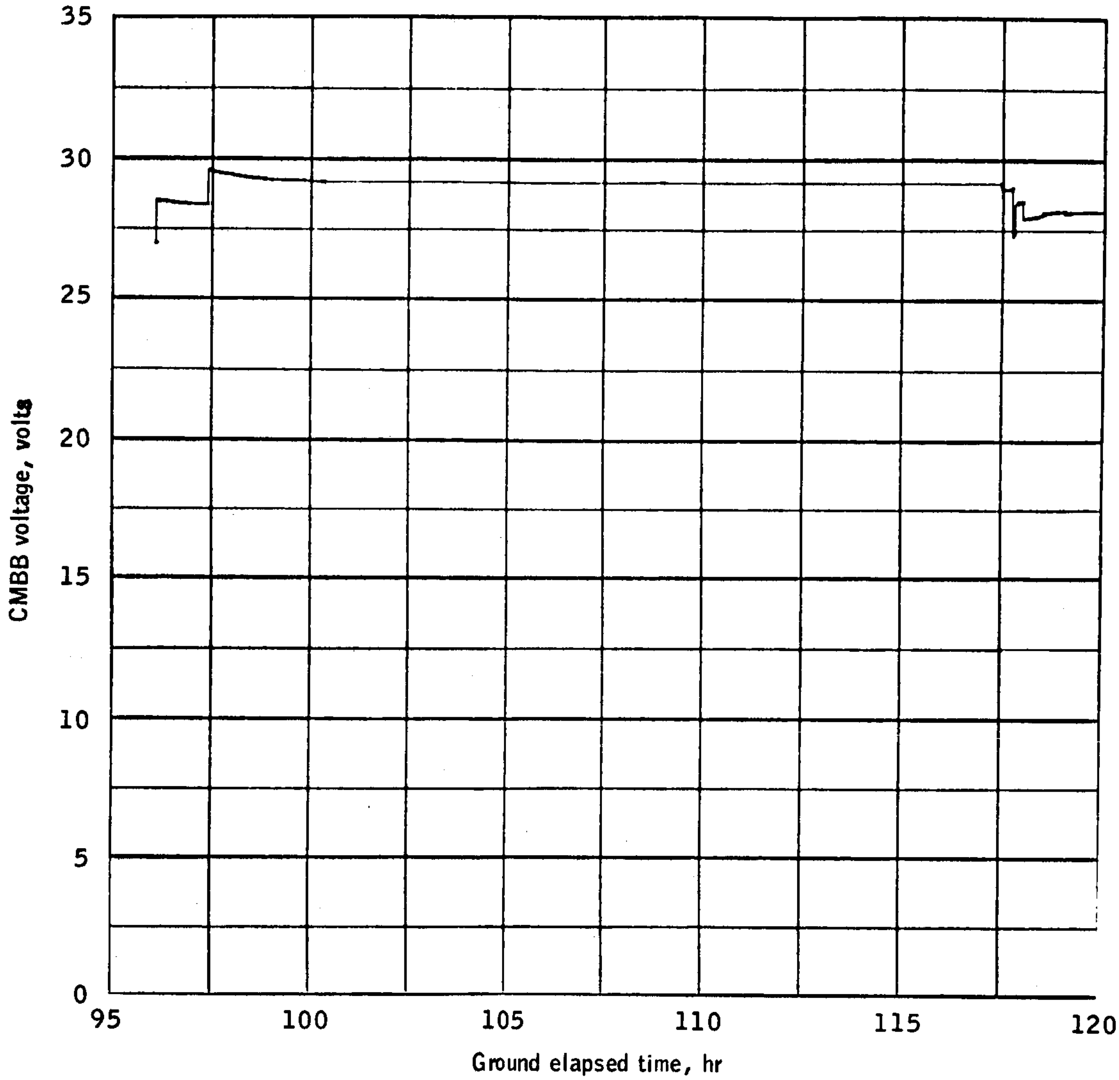
(c) 48 hours to 72 hours, ground elapsed time.

Figure 13.- Continued.



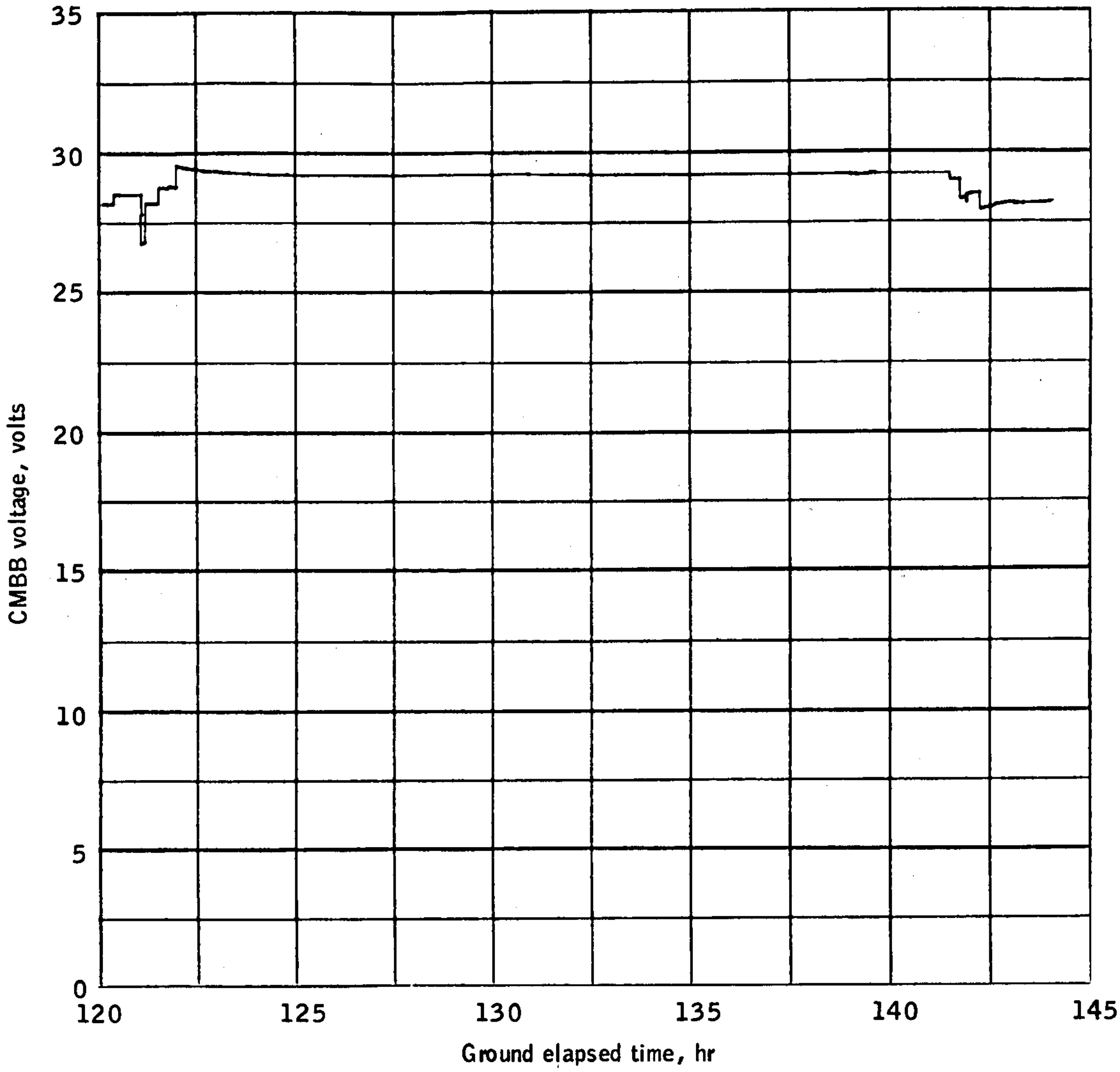
(d) 72 hours to 96 hours, ground elapsed time.

Figure 13.- Continued.



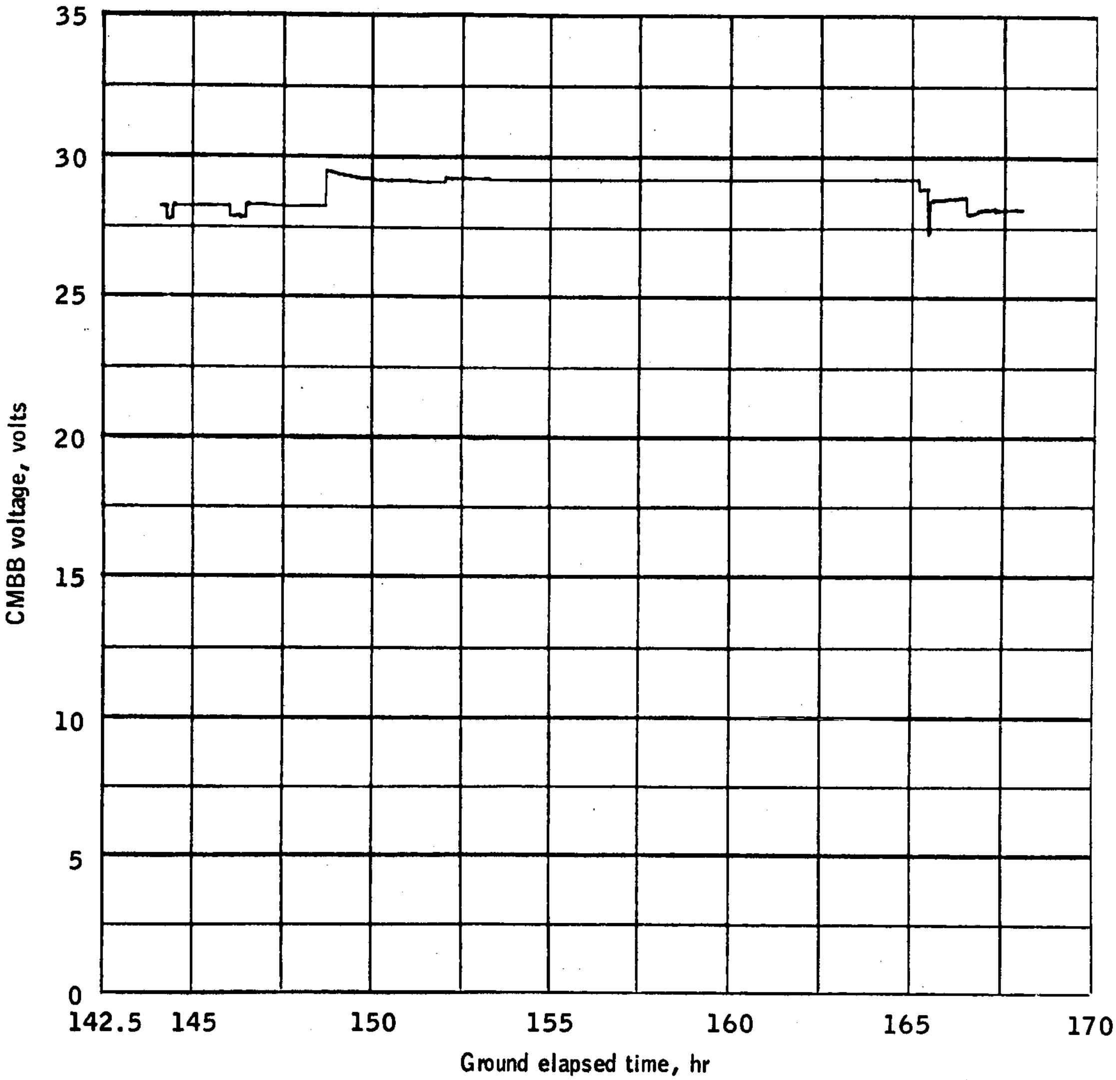
(e) 96 hours to 120 hours, ground elapsed time.

Figure 13.- Continued.



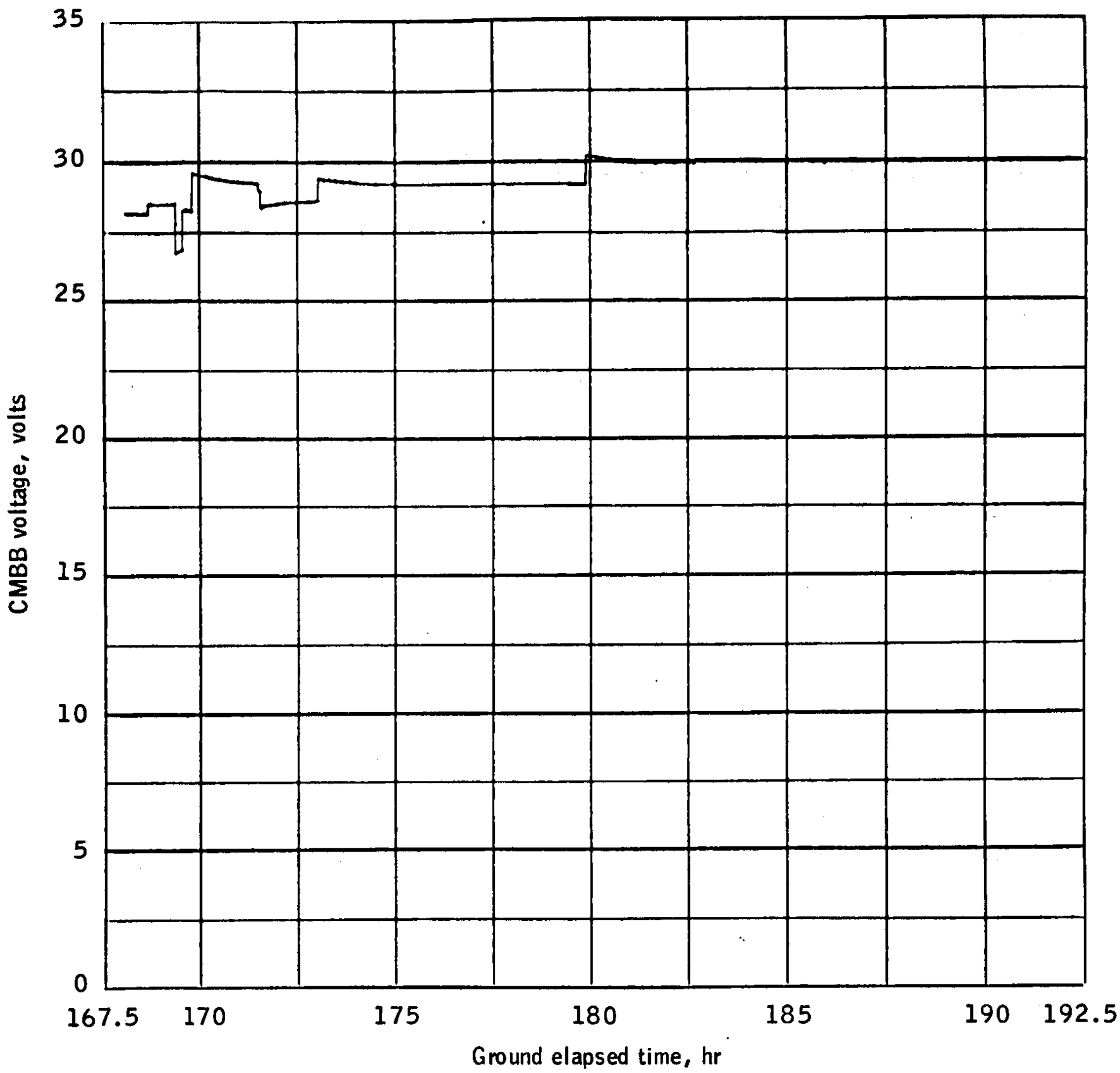
(f) 120 hours to 144 hours, ground elapsed time.

Figure 13.- Continued.



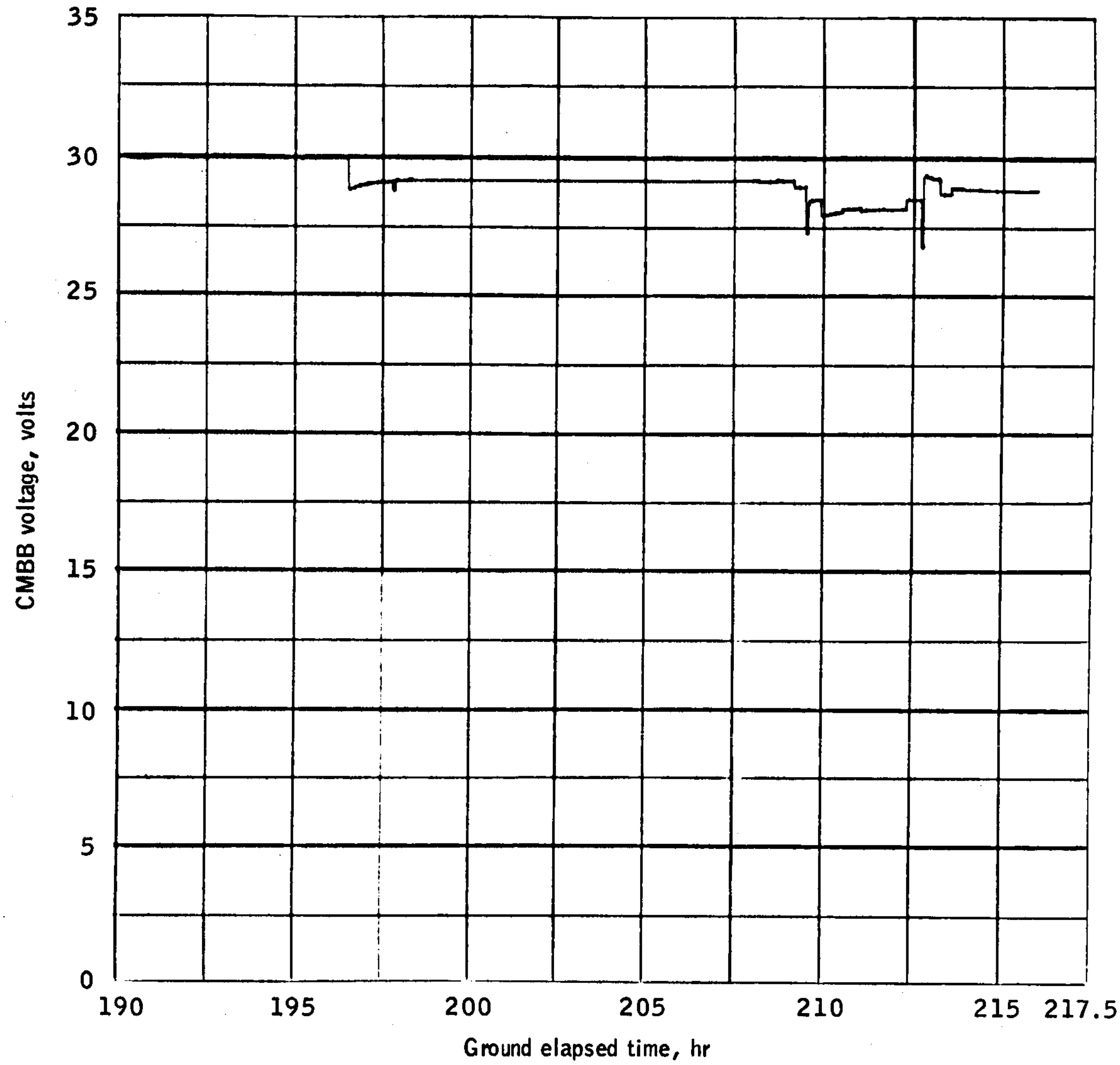
(g) 144 hours to 168 hours, ground elapsed time.

Figure 13.- Continued.



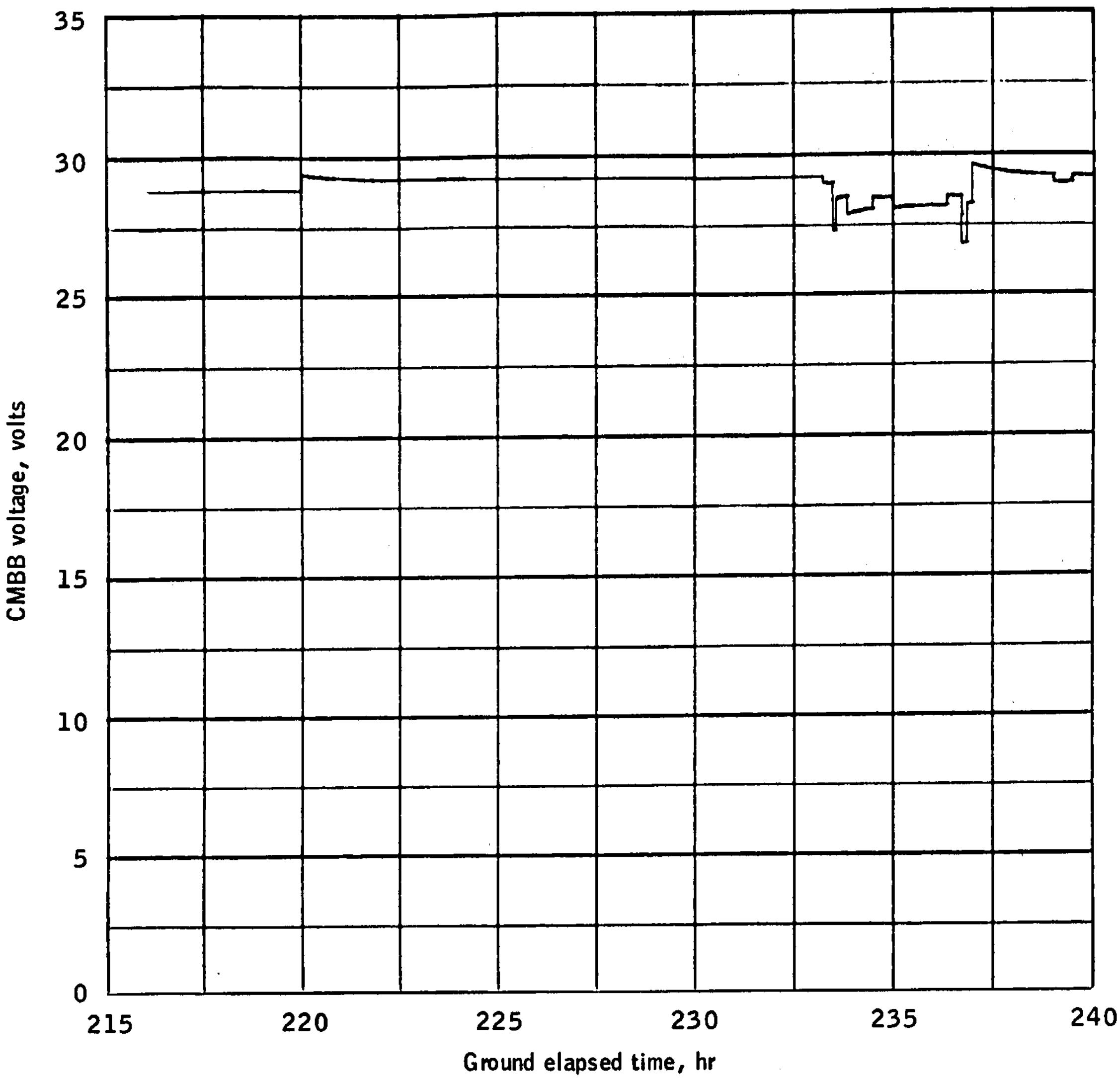
(h) 168 hours to 192 hours, ground elapsed time.

Figure 13.- Continued.



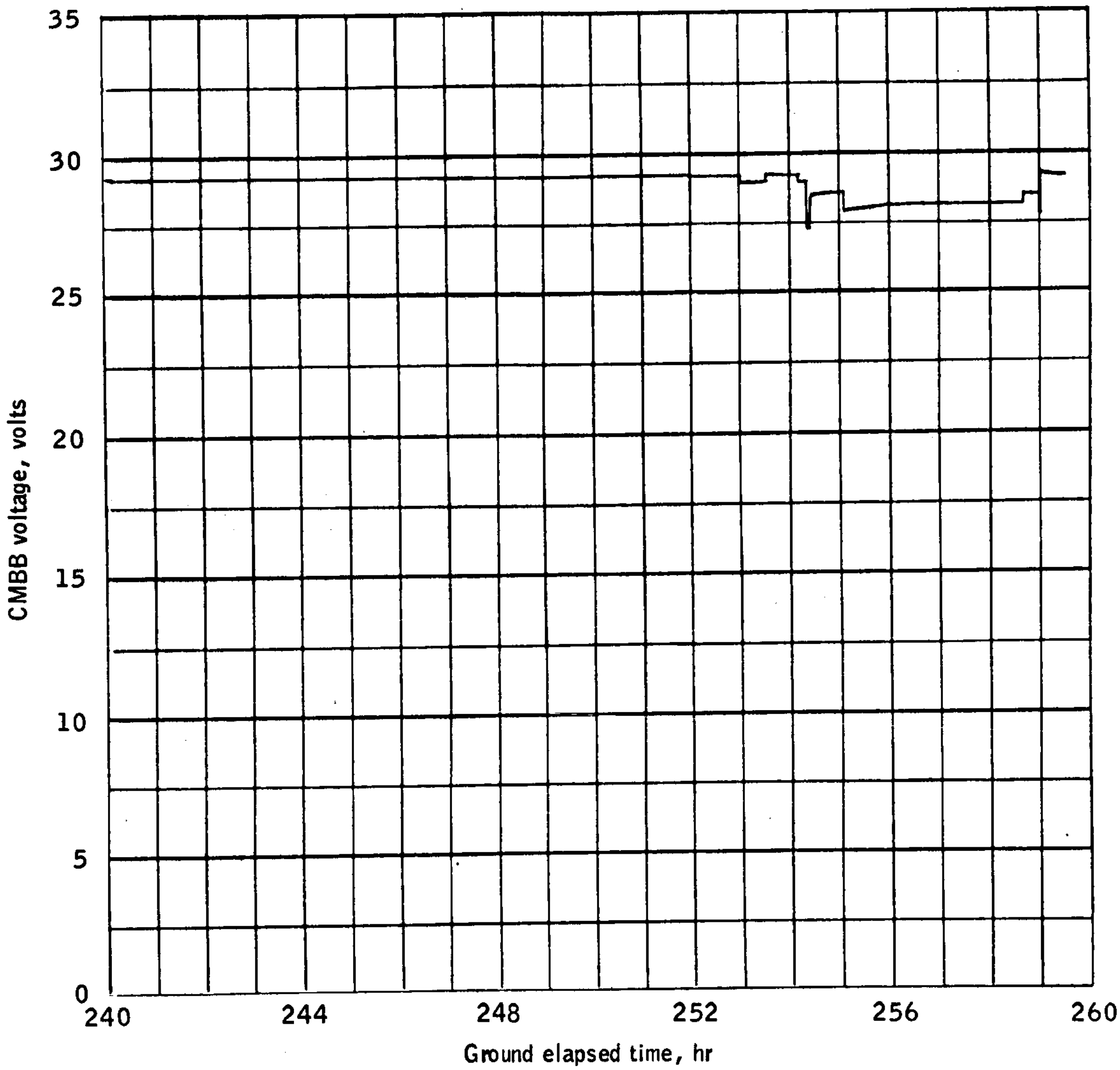
(i) 192 hours to 216 hours, ground elapsed time.

Figure 13.- Continued.



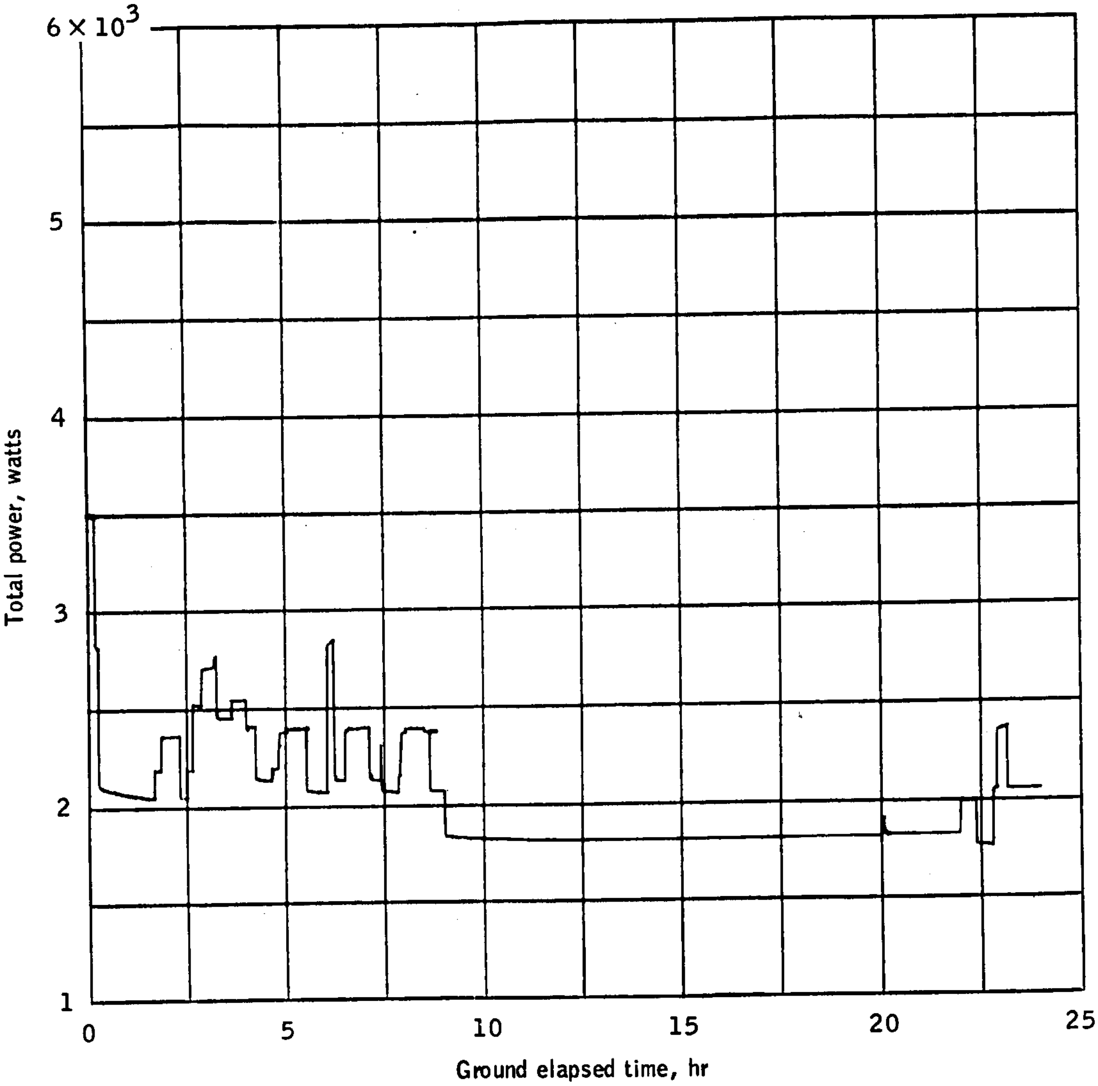
(j) 216 hours to 240 hours, ground elapsed time.

Figure 13.- Continued.



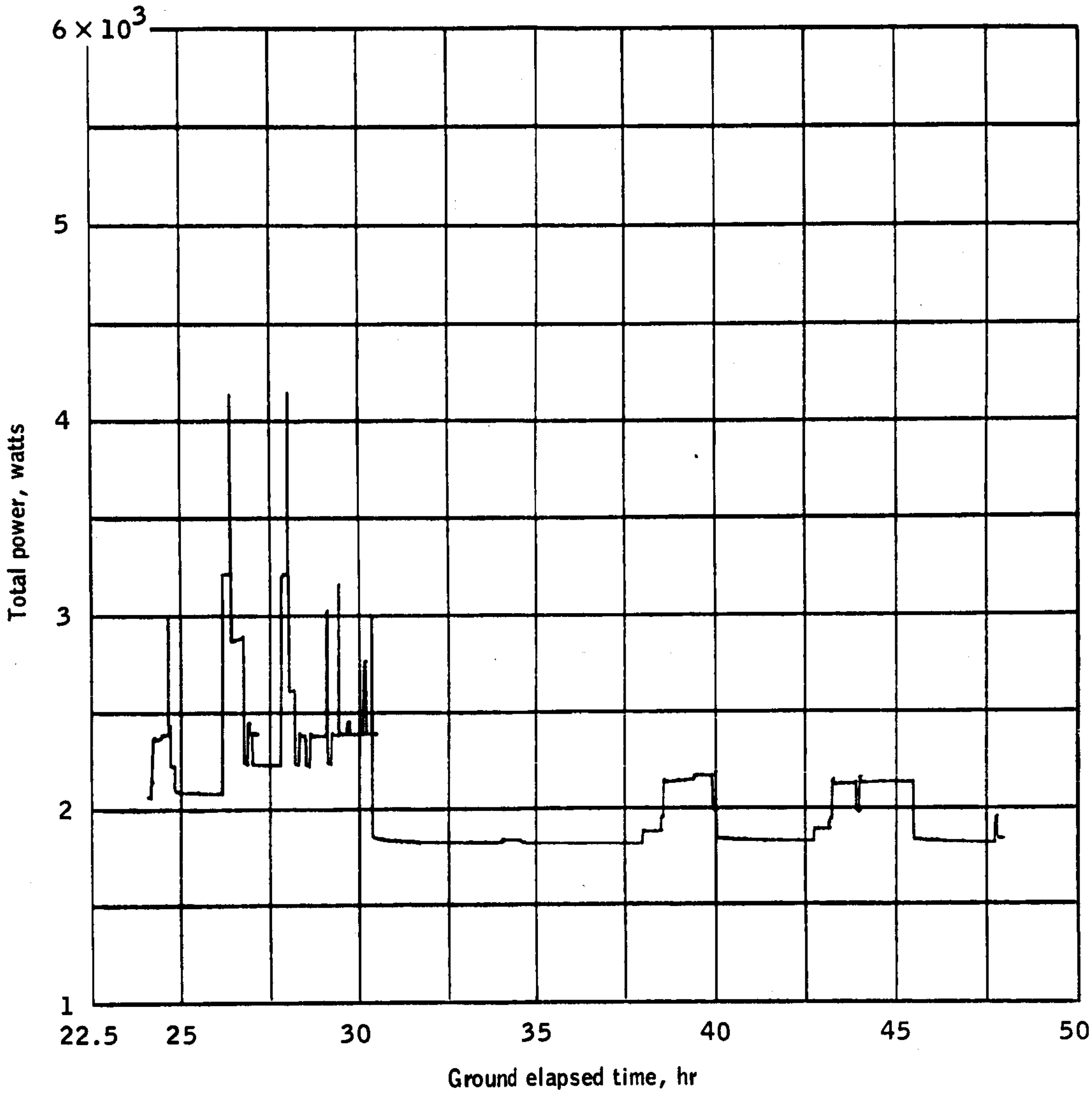
(k) 240 hours to 260 hours, ground elapsed time.

Figure 13.- Concluded.



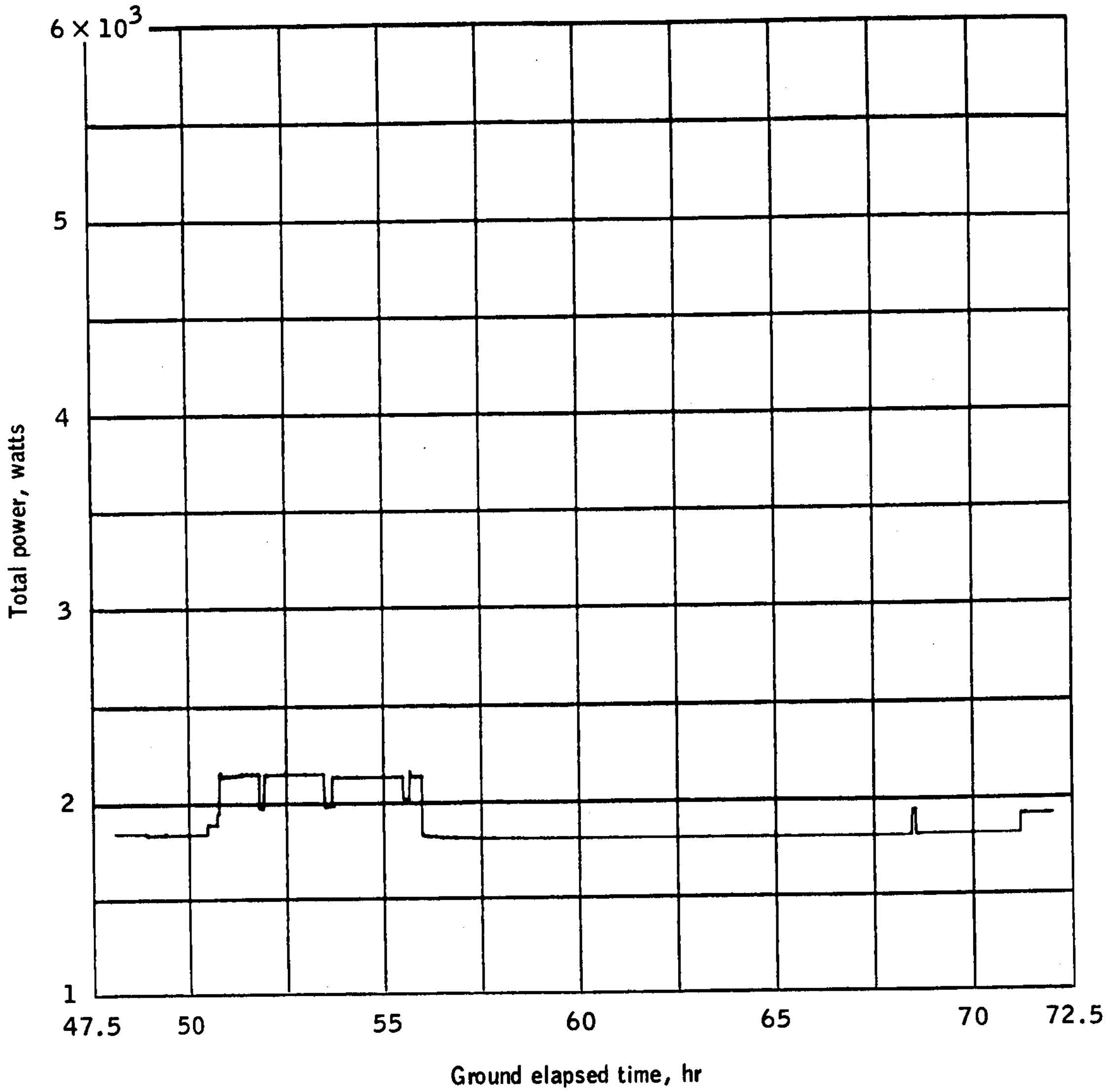
(a) Lift-off to 24 hours, ground elapsed time.

Figure 14.- Time history of total power.



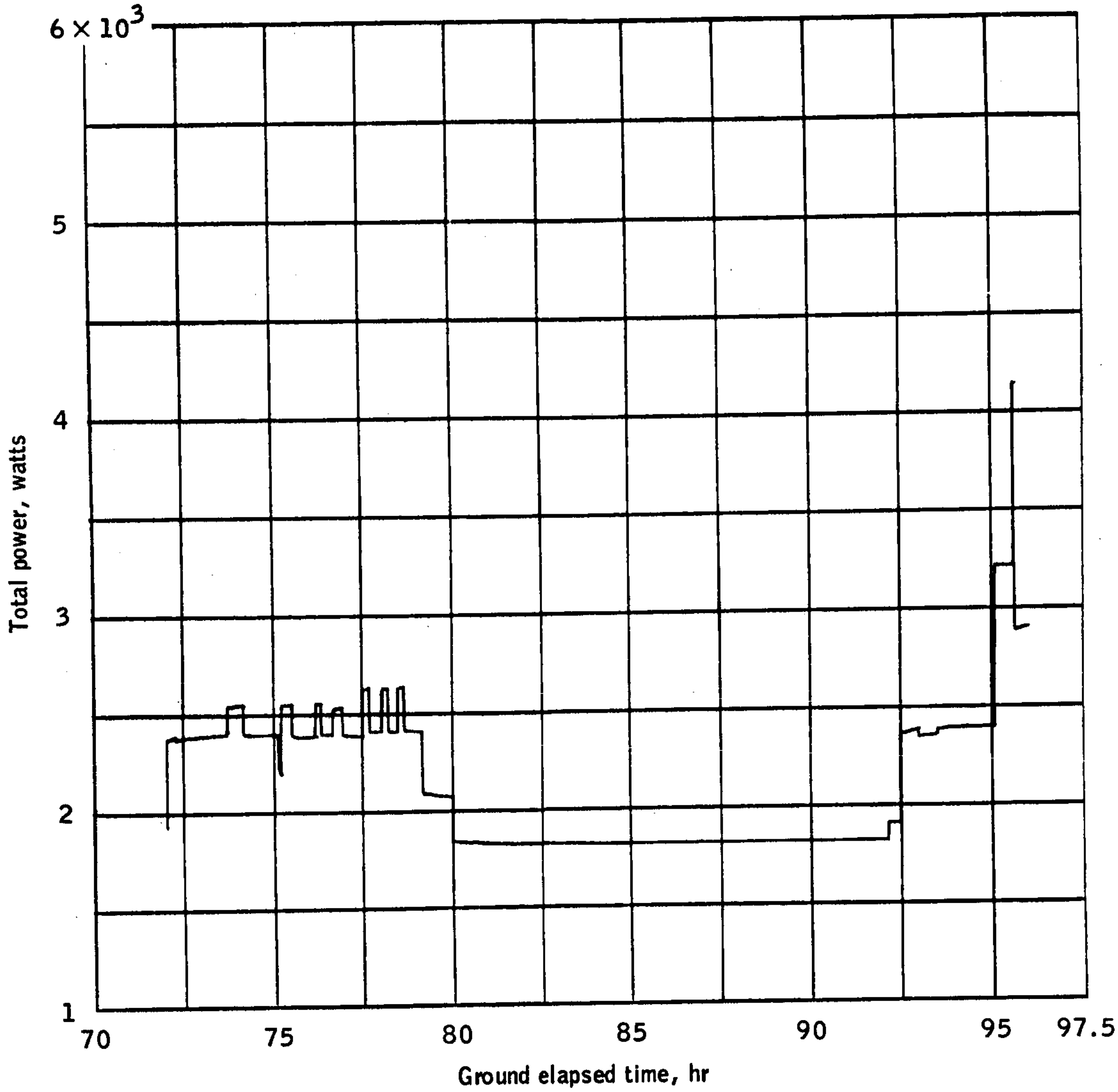
(b) 24 hours to 48 hours, ground elapsed time.

Figure 14.- Continued.



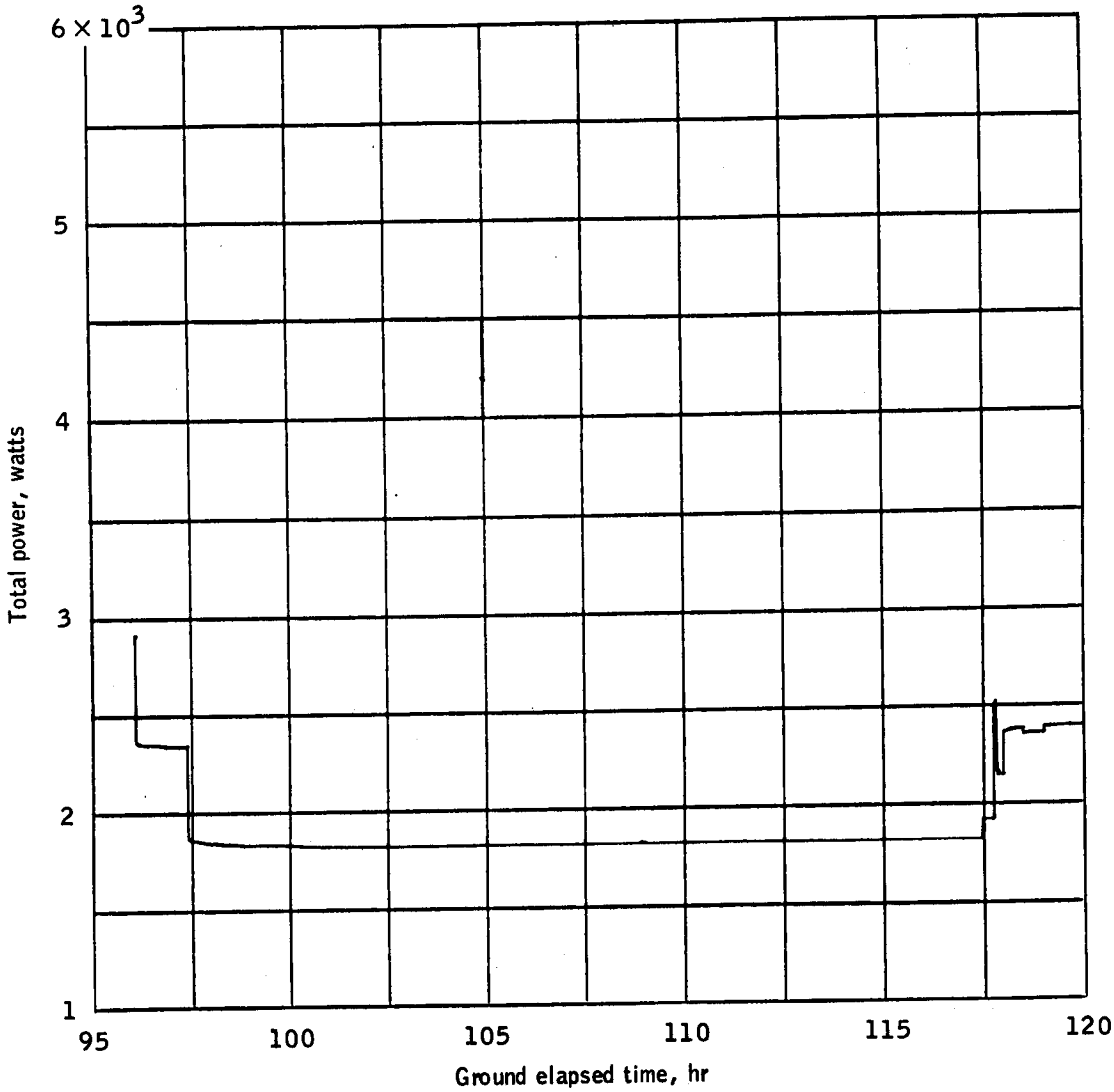
(c) 48 hours to 72 hours, ground elapsed time.

Figure 14.- Continued.



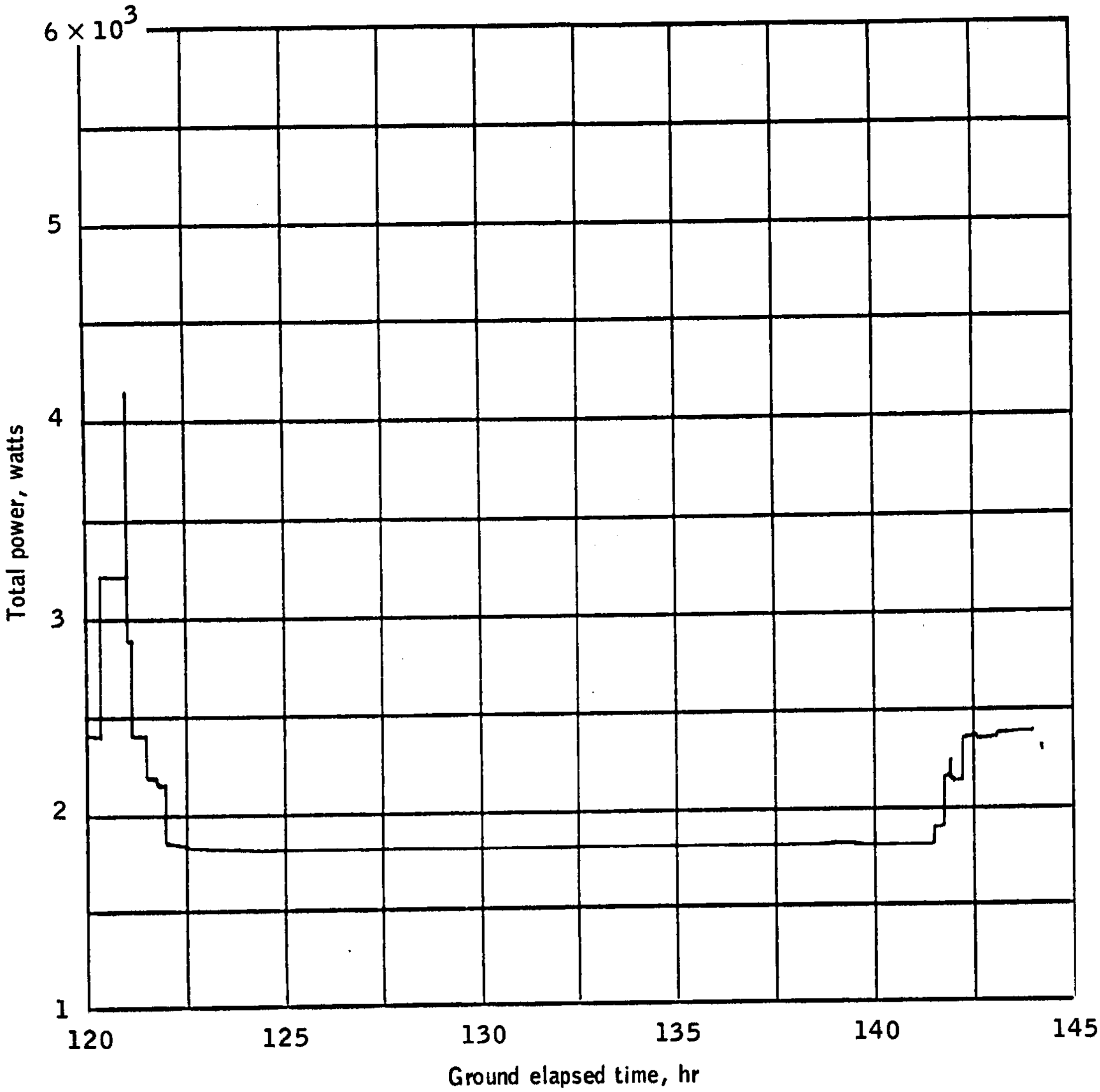
(d) 72 hours to 96 hours, ground elapsed time.

Figure 14.- Continued.



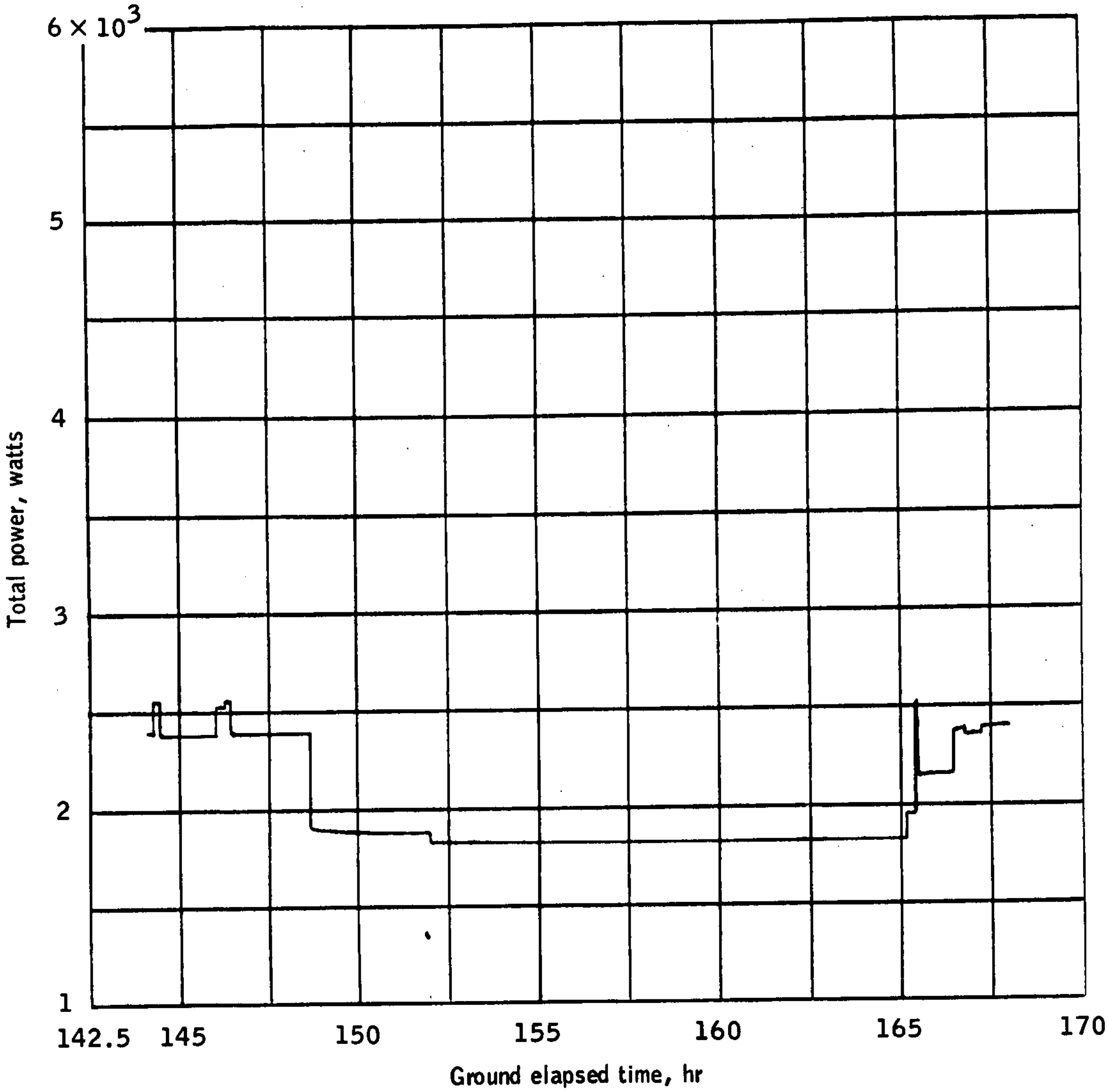
(e) 96 hours to 120 hours, ground elapsed time.

Figure 14.- Continued.



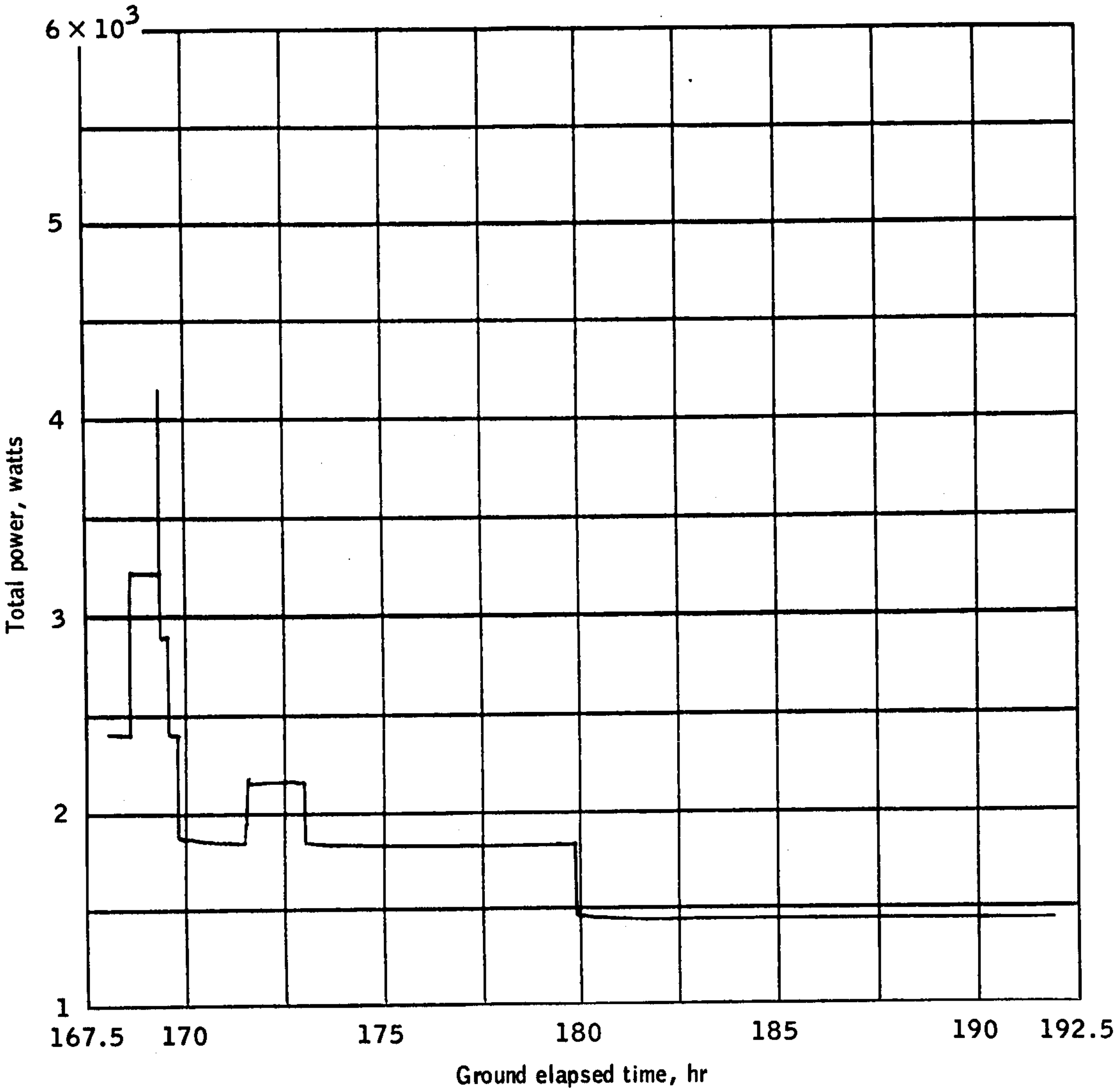
(f) 120 hours to 144 hours, ground elapsed time.

Figure 14.- Continued.



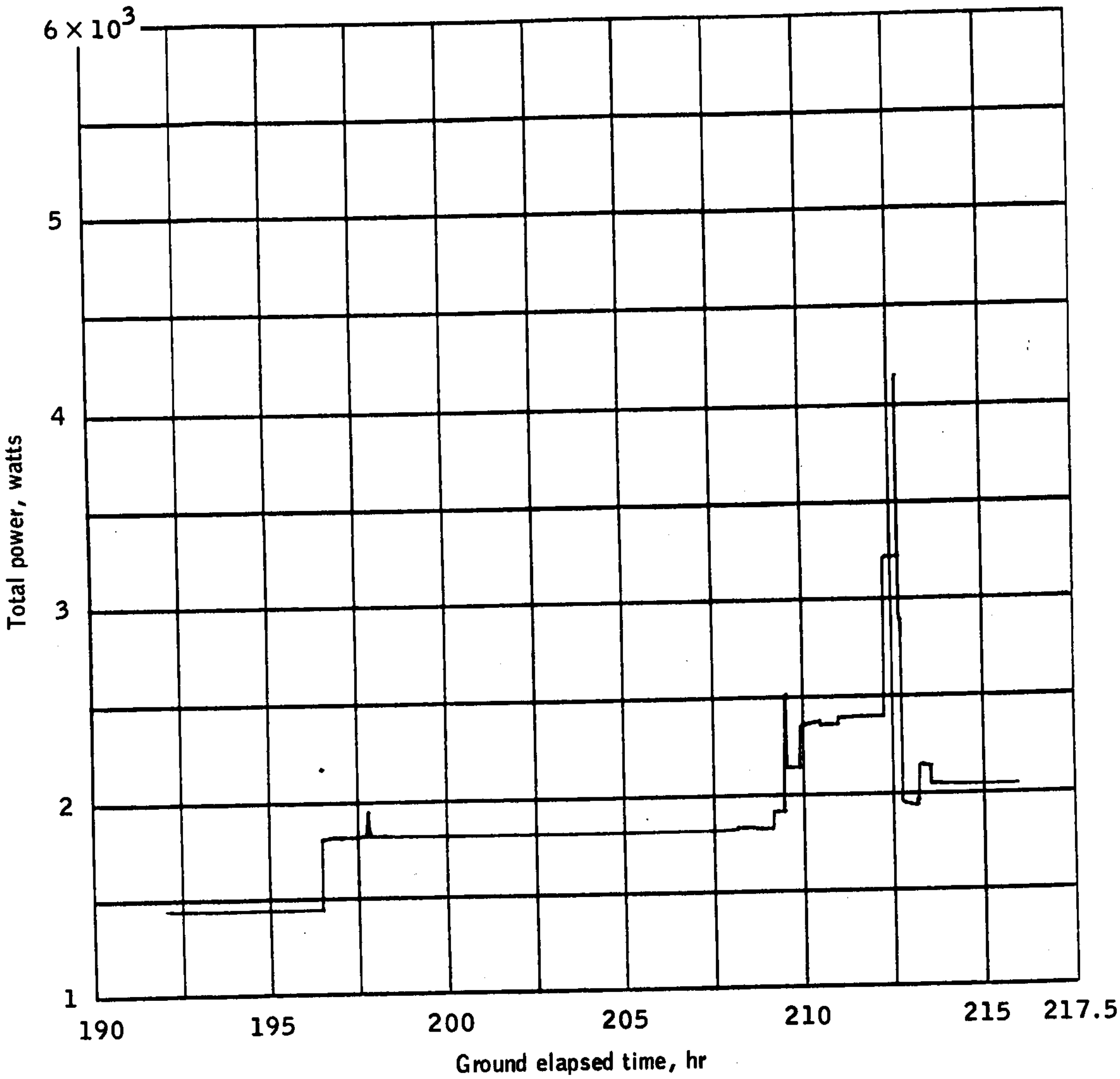
(g) 144 hours to 168 hours, ground elapsed time.

Figure 14.- Continued.



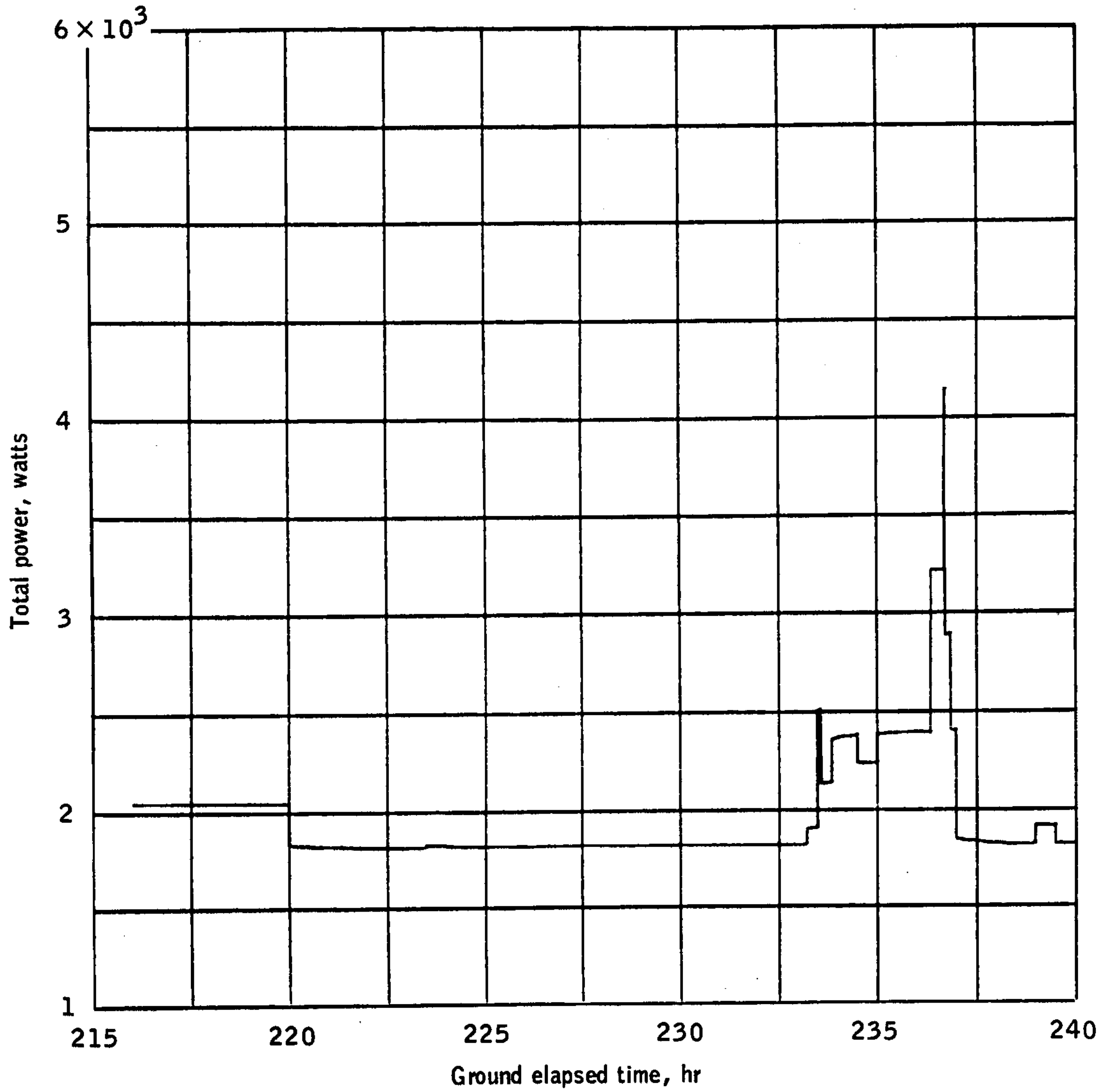
(h) 168 hours to 192 hours, ground elapsed time.

Figure 14.- Continued.



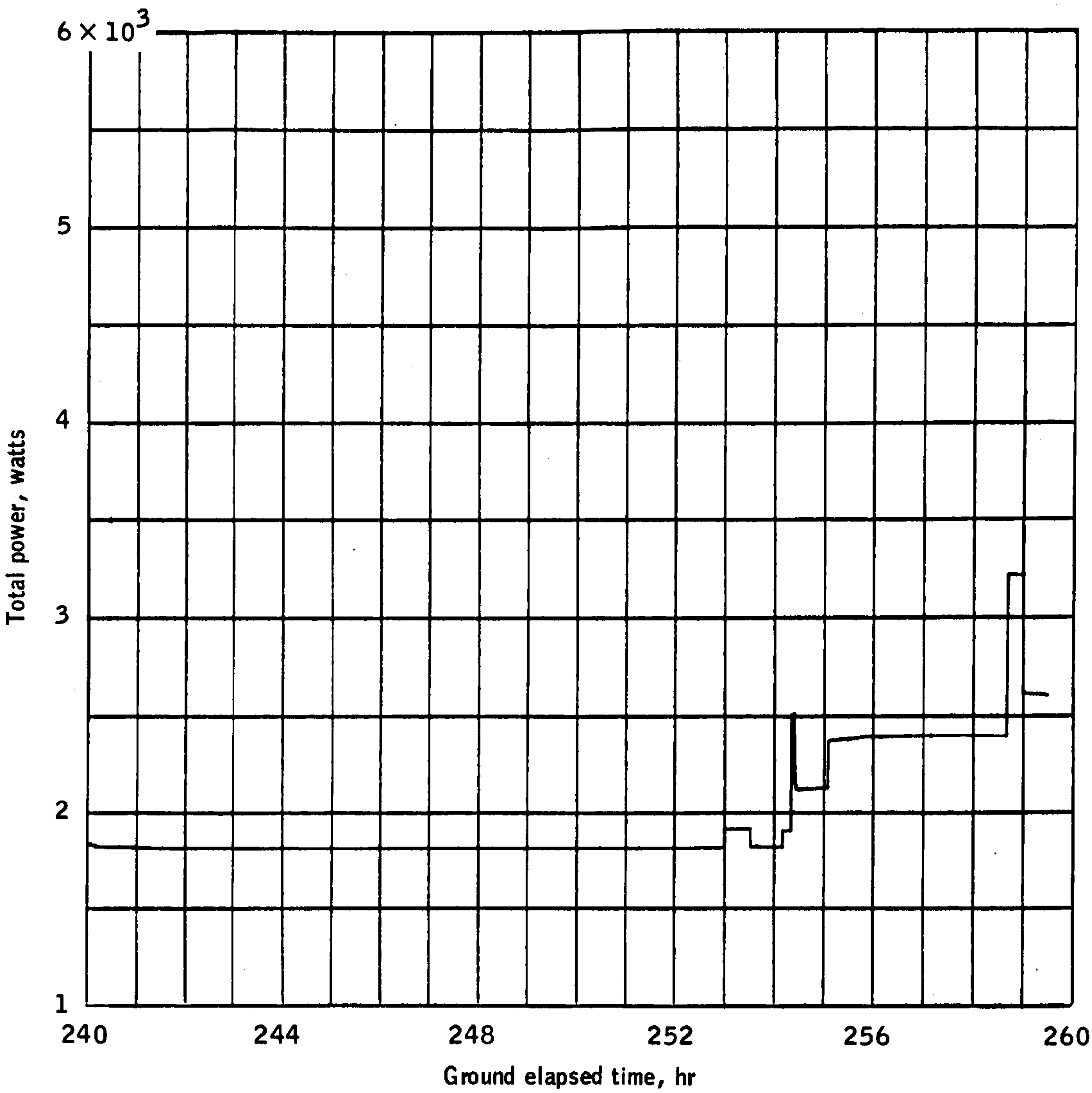
(i) 192 hours to 216 hours, ground elapsed time.

Figure 14.- Continued.



(j) 216 hours to 240 hours, ground elapsed time.

Figure 14.- Continued.



(k) 240 hours to 260 hours, ground elapsed time.

Figure 14.- Concluded.

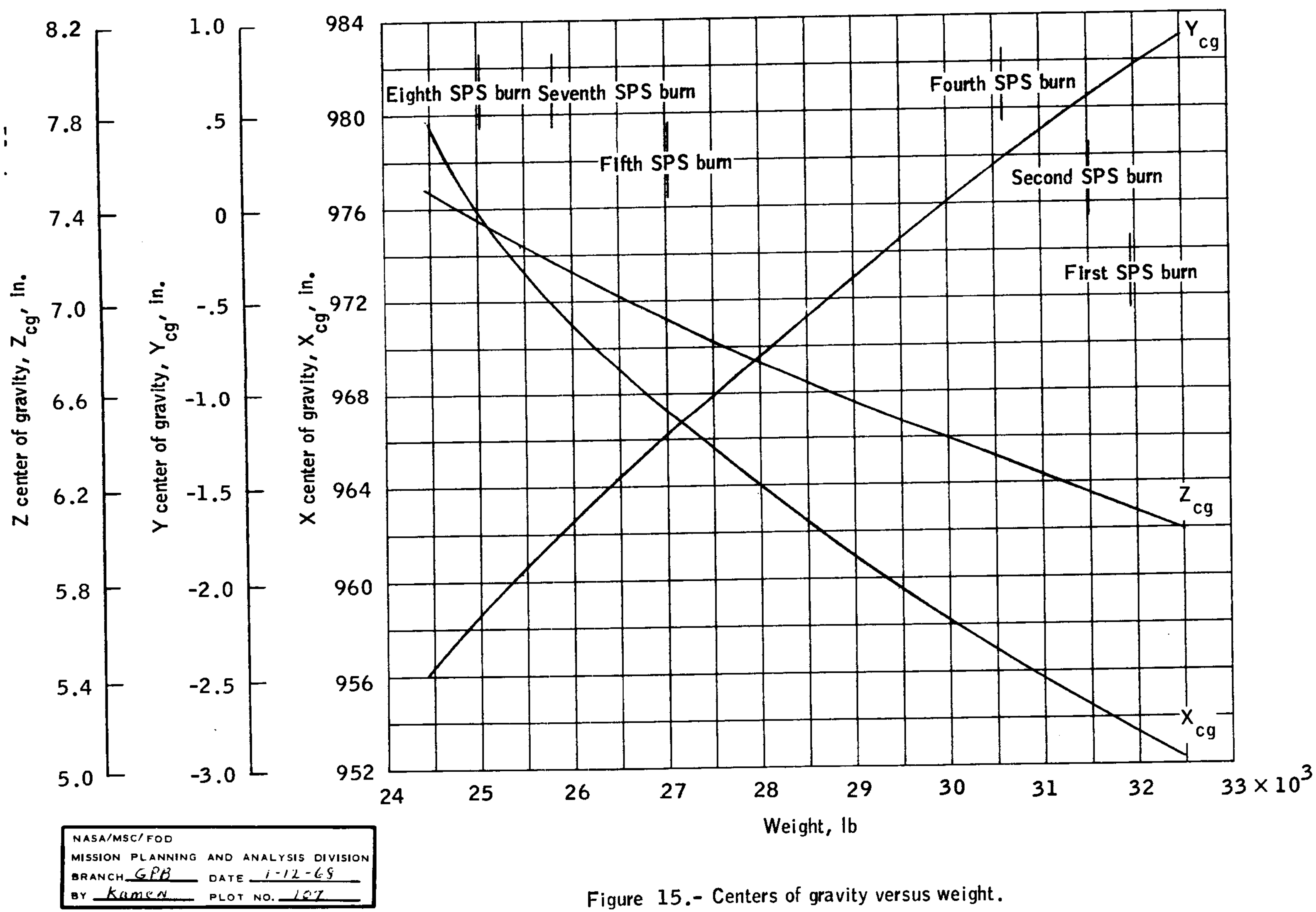


Figure 15.- Centers of gravity versus weight.

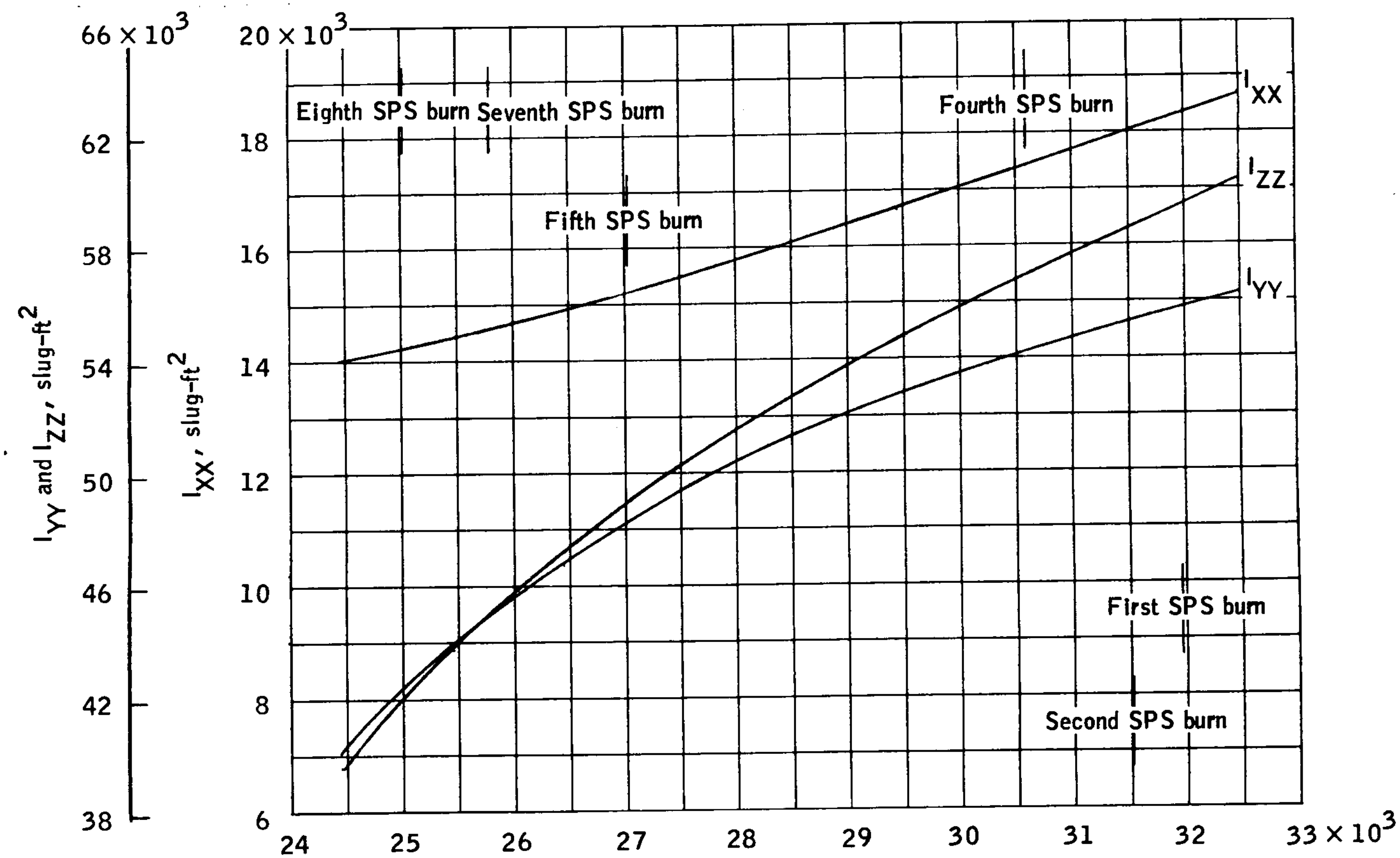


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Figure 16.- Moments of inertia versus weight.

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